इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

IS 14957 (2001): Aerial Devices with Insulating Boom Used for Live Working [ETD 36: Tools and Equipment for Live Working]

“ज्ञान से एक नये भारत का निर्माण”
Satyanarayan Gangaram Pitroda
“Invent a New India Using Knowledge”

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartṛhari—Nītiśatakam
“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

IS 14957 : 2001
IEC 61057 (1991)

भारतीय मानक

चालू बिजली पर कार्य में प्रयुक्त विद्युतरोधी बूम सहित एरियल युक्तियाँ

Indian Standard

AERIAL DEVICES WITH INSULATING BOOM USED FOR LIVE WORKING

ICS 13.260; 29.240.20; 29.260.99

© BIS 2001

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 2001

Price Group 15

Tools and Equipment for Live Working Sectional Committee, ET 36

NATIONAL FOREWORD

This Indian Standard which is identical with IEC 1057 (1991) [renumbered as IEC 61057 (1991)] 'Aerial devices with insulating boom used for live working' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Tools and Equipment for Live Working Sectional Committee and approval of the Electrotechnical Division Council.

This standard specifies the specialized technical characteristics tests and checks applicable to insulating parts of aerial devices commonly known as Mobile Elevating Work Platforms (MEWP) used for live working on the nominal voltages, which is between 1 kV r.m.s and 800 kV r.m.s. at power frequency.

The text of the IEC Standard has been approved as suitable for publication as Indian Standard without deviations.

In the adopted standard, certain terminology and conventions are not identical to those used in Indian Standards. Attention is specially drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Only the English text of the International Standard has been retained while adopting it in this Indian Standard.

CROSS REFERENCES

In this adopted standard, reference appears to certain International Standard for which Indian Standard also exists. The corresponding Indian Standard, which is to be substituted in its place, is listed below along with its degree of equivalence for the edition indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60060-1 (1989) High voltage test techniques — Part 1: General definitions and test requirements	IS 2071 (Part 1) : 1993 High voltage test techniques: Part 1 General definitions and test requirements (*second revision*)	Identical
IEC 60270 (1981) Partial discharge measurements	IS 6209 : 1982 Methods for partial discharge measurement (*first revision*)	Equivalent
IEC 60296 (1982) Specification for unused mineral insulating oils for transformers and switchgear	IS 335 : 1993 New insulating oils (*fourth revision*)	Not Equivalent
IEC 60475 (1974) Method of sampling liquid dielectrics	IS 6855 : 1973 Method of sampling for liquid dielectrics	Equivalent
IEC 60707 (1999) Flammability of solid nonmetallic materials when exposed to flame sources — List of test methods	IS 11731 (Part 1) : 1986 Methods of test for determination of the flammability of solid electrical insulating materials when exposed to an igniting source: Part 1 Horizontal specimen method	Not Equivalent

(*Continued on third cover*)

CONTENTS

Page

Clause

SECTION 1 - GENERAL

1 Scope 5

2 Definitions 6

2.1 Definitions according to IEV 6
2.2 Specific definitions 6
2.3 Nomenclature 10

SECTION 2 - TECHNICAL CHARACTERISTICS

3 Special technical characteristics 12

3.1 Dimensions 12
3.2 Special devices to ensure safety 12
3.2.1 Stabilization of buckets 12
3.2.2 Personnel safety attachments 13
3.2.3 Controls 13
3.2.4 Auxiliary power system 14
3.2.5 Rotation of the turntable 14
3.2.6 Communication 14
3.3 Other characteristics 14

4 Particular electrical characteristics 14

4.1 Earthing 14
4.2 Electrostatic discharge protection of metal components 14
4.3 Corona effect 14
4.3.1 Equipotential connection between conducting parts which are not insulated from each other 14
4.3.2 Guard electrode 15
4.3.3 Non-visible conductive parts 15
4.4 Bonding equipment 15
4.4.1 Bonding cable 15
4.4.2 Equipotential bonding 15
4.5 Monitoring of leakage current 16

Clause Page

SECTION 3 - TYPE TESTS

5 General ... 16

6 Visual inspection and dimensional check ... 16

- 6.1 Visual inspection ... 16
- 6.2 Dimensional check ... 16

7 Dye penetration test of insulating foam-filled structures ... 16

8 Electrical tests ... 17

- 8.1 Electrical tests before and after exposure to humidity for the boom, rods, hoses, optical fibre cables and hollow tubes ... 17
  - 8.1.1 Boom ... 17
  - 8.1.2 Tubes and rods ... 18
  - 8.1.3 Hoses ... 18
  - 8.1.4 Optical fibre cable ... 20
  - 8.1.5 Hollow tubes ... 21
- 8.2 Dielectric wet test for the boom, rods, hoses, optical fibre cables and hollow tubes ... 21
  - 8.2.1 General test conditions ... 21
  - 8.2.2 Wet conditions ... 21
  - 8.2.3 Test results ... 22
- 8.3 Electrical test for oil and devices employing oil ... 22
- 8.4 Special requirements for hollow booms ... 22
  - 8.4.1 Sealed hollow boom ... 22
  - 8.4.2 Open hollow boom ... 22
- 8.5 Dielectric tests of the aerial devices ... 23
  - 8.5.1 Dielectric tests of the complete boom ... 23
  - 8.5.2 Dielectric test of a lower boom with an insulating insert ... 25
- 8.6 Dielectric test on insulating buckets and liners ... 25
  - 8.6.1 Puncture test ... 25
  - 8.6.2 Surface withstand test ... 26
- 8.7 Jibs ... 26

9 Mechanical tests ... 26

- 9.1 Fatigue test ... 26
  - 9.1.1 Fatigue type test on upper boom and lower boom with insulating insert ... 26
  - 9.1.2 Fatigue type test on insulating hoses ... 26
- 9.2 Overload test ... 27
  - 9.2.1 Overload test on boom and jib ... 27
  - 9.2.2 Torsion test on boom with bucket(s) ... 28

Clause Page

9.3 Hydrostatic tests 28
9.3.1 Bursting safety factors 28
9.3.2 Hydrostatic tests on insulating hoses 28
9.3.3 Impulse test on insulating hoses 28
9.3.4 Leakage test on insulating hoses 29
9.3.5 Change in length test on insulating hoses 29
9.3.6 Burst test on insulating hoses 30
9.3.7 Cold bend test on insulating hoses 30
9.4 Oil depressurization 30

10 Mechanical factors that affect the use of a mobile unit during live working 31

10.1 Boom deflection 31
10.2 Horizontal bucket loading 31
10.3 Bucket creep 31
10.4 Bucket tilt angle 31
10.5 Precision of upper controls at the bucket 31

11 Determination of the flammability for insulating buckets and liners 31

SECTION 4 - SAMPLING AND ROUTINE TESTS

12 Sampling tests 32

13 Routine tests 32

13.1 Visual inspection 32
13.2 Operation 32
13.3 Dielectric tests 32
13.4 Mechanical tests 32
13.5 Acoustic emission test method 33
13.6 Determination of device stability 33

SECTION 5 - SPECIAL CLAUSES

14 Marking 33

15 Modifications 33

16 Acceptance tests 33

APPENDIX A – Electrical tests before and after exposure to humidity 34

APPENDIX B – Dielectric wet test 43

APPENDIX C – Electrical tests for aerial devices 44

Clause Page

APPENDIX D – Fatigue test of insulating hoses 49

APPENDIX E – Overload test 51

APPENDIX F – Marking 53

APPENDIX G – Acceptance tests 54

APPENDIX H – Specific terms and nomenclature 55

APPENDIX J – Details of typical boom current monitoring system 59

APPENDIX K – User's guide 61

APPENDIX L – Acoustic emission on aerial devices with insulating booms - Test method 62

IS 14957 : 2001
IEC 61057 (1991)

Indian Standard

AERIAL DEVICES WITH INSULATING BOOM USED FOR LIVE WORKING

SECTION 1 - GENERAL

1 Scope

This standard is applicable to aerial devices (mobile elevating work platforms [MEWP]), with or without the possibility of an additional jib, as a minimum with an insulating upper boom (extending structure), used for live working on the nominal voltage, which is between 1 kV r.m.s. and 800 kV r.m.s., at power frequency.

The application of some parts of this standard to d.c. systems is still under consideration.

This standard specifies:

- the specialized technical characteristics, tests and checks of the insulating parts (boom, extending structure, transmission of controls along the boom, work platform, bucket, accessories, jibs, etc.) required for live working;
- the technical characteristics, tests and checks of conducting parts, the conductive properties which are essential for positioning near to, or at, the potential of the live element (part) to be worked on;
- the special characteristics which are not necessarily subjected to test, but which are fundamental for ensuring the safety and precision essential to safe working on live parts.

Excluded from this standard, but to be observed:

- specifications applicable to all kinds of aerial devices (mobile elevated work platforms) which are covered by applicable international standards or national regulations, for example design, calculations, stability requirements, roadway code, employment regulations, etc.;
- specifications for those parts of the aerial device (carrier, etc.) not specific to live working;
- specifications for personnel electrostatic shielding equipment (the user should provide adequate shielding equipment in accordance with national regulations).

2 Definitions

2.1 *Definitions according to IEV*

Flashover

An arc by-passing an insulating body (IEV 121-03-14).

Puncture

A disruptive breakdown through a solid insulant (IEV 121-03-13).

Sparkover

A disruptive discharge: passage of an arc following dielectric breakdown.

NOTE - The term "sparkover" is used when a disruptive discharge occurs in a gaseous or liquid dielectric. The term "flashover" is used when a disruptive discharge occurs over the surface of a solid dielectric in a gaseous or liquid medium. The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

Type test

A test of one or more devices made to a certain design to show that the design meets certain specifications (IEV 151-04-15).

Routine test

A test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria (IEV 151-04-16).

Sampling test

A test on a number of devices taken at random from a batch (IEV 151-04-17).

Acceptance test

A contractual test to prove to the customer that the device meets certain conditions of its specification (IEV 151-04-20).

2.2 *Specific definitions*

Aerial device

Any device which is primarily designed to position persons and to handle materials.

NOTE - This device does not include the chassis.

Chassis

A vehicle on which the aerial device will be mounted, such as a commercial vehicle, trailer or all terrain vehicle.

NOTE - The chassis (supporting vehicle) may be the base of a mobile elevating work platform (MEWP) and it may be pulled, pushed, self-propelled, vehicle-mounted, etc.

Mobile unit

A combination of an aerial device, its carrier and related equipment. See Figure H1 of Appendix H - the letters (*A*), (*B*), etc. are referenced.

Model

Manufacturer's designation for aerial device specified.

Platform height of the mobile unit (*A*)

The height at maximum elevation from platform floor to ground.

Horizontal reach (*B*)

The maximum distance reached from the centreline of the rotating turntable to the outer edge of the platform.

Outrigger height (*C*)

The distance from ground level to the bottom of retracted outriggers.

Outrigger penetration (below ground level) (*D*)

The distance below ground level which the outriggers can reach when fully extended.

Outrigger spread (at ground level) (*E*)

The distance between the outer edges on fixed pads, or between pins on pivoted pads, of opposite outriggers resting on level ground.

Outrigger spread (at maximum extension) (*F*)

The distance between the outer edges on fixed pads, or between pins on pivoted pads, of opposite outriggers when fully extended.

Chassis height (*G*)

The height from ground level to the top of the chassis frame rail.

Rear axle centreline

The location of the combination moment equivalent for the centrelines of one, two, three or more rear axles (see Figure H1A of Appendix H).

Wheel base (*WB*)

The distance between the front and rear axle centrelines of the chassis recommended for mounting the aerial device.

Cab-axle dimension (*CA*)

The distance between the back of the cab and the rear axle centreline of the chassis recommended for mounting the aerial device.

Front projection (*FP*)

The maximum distance of any part of the aerial device forward of the front axle centreline when stowed for travel.

Rear projection (*RP*)

The maximum distance of any part of the aerial device behind the rear axle centreline when stowed for travel.

Front overhang (*FO*)

The maximum distance of any part of the aerial device forward of the front bumper.

Rear overhang (*RO*)

The maximum distance of any part of the aerial device behind the rear bumper.

Overall length (*OL*)

The maximum distance of any part of the aerial device or the truck between the front and the back.

Aerial device centre of gravity – horizontal (*K*)

The horizontal component of the distance from the axis of rotation to the centre of gravity of the aerial device in the stowed position.

Aerial device centre of gravity – vertical (*L*)

The vertical component of the distance above the mounting surface of the aerial device to the centre of gravity of the aerial device in the stowed position.

Insulation gap (upper boom) (*M*)

The minimum insulated length of the upper boom and its components.

Insulation gap (lower boom) (*N*)

The minimum insulated length of the lower boom and its components.

Centre of rotation location (*H*)

The distance from the centreline of the rear axle to the axis of rotation of the turntable.

Travel height (stowed) (*J*)

The overall height from ground level to the highest point on the aerial device when stowed for travel.

Rated capacity (*P*)

The capacity is of two distinct types and in both cases shall be determined with booms extended to a position of maximum over-hanging moment attainable through the full rotation of the turntable.

Capacities in other positions shall be specified separately.

Platform capacity is the maximum load in kilograms for which the aerial device is designed to operate under the above conditions. Supplemental capacity is the maximum additional load, in kilograms, applied to the booms by jibs and for specified boom positions.

Aerial device weight (*W*)

Weight of the standard aerial device, less optional counterweights, accessories and auxiliary equipment.

Lower boom travel up (*a*)

The maximum angle reached by the lower boom measured above the horizontal axis passing through the lower boom pin.

Lower boom travel down (*b*)

The maximum angle reached by the lower boom measured below a horizontal axis passing through the lower boom pin.

Turntable rotation (*c*)

The range of turntable rotation, in either direction, expressed as continuous or non-continuous, specified in angular degrees.

Upper boom travel up (*d*)

The maximum angle reached by the upper boom measured above a horizontal axis passing through the elbow pin at its maximum height.

Upper boom travel down (*e*)

The maximum angle reached by the upper boom measured below a horizontal axis passing through the elbow pin at its maximum height.

Rated voltage of the aerial device (U_d)

The maximum use voltage between the upper boom tip and the elbow of the mobile unit at power frequency (see Appendix K and Figure H2 of Appendix H).

NOTE - This corresponds to the maximum r.m.s. line to ground voltage of a three-phase system.

2.3 *Nomenclature* (the numbers (1), (2), etc. are referenced - see Figure H2 of Appendix H)

Upper controls (1)

Those controls located in or beside the platform, and designed for the movement functions of the aerial device and other functions (e.g., control of the winch).

Platform (2)

The personnel-carrying component of an aerial device, such as a bucket.

Platform or bucket pin (3)

The horizontal pin about which the platform or bucket moves relative to the upper boom.

Upper boom tip (4)

The end of the upper boom to which the platform is attached.

Upper boom (5)

The insulating structural member attached to the lower boom, or to an extendable structure, which supports the platform.

Upper boom cylinder (6)

The hydraulic cylinder which articulates the upper boom.

Upper boom drive mechanism (7)

Means, such as linkage, cables, sheaves and gears, used to produce upper boom articulation.

Elbow (8)

The structure connecting the upper boom to the lower boom, about which one articulates relative to the other.

Elbow pin (9)

The horizontal pin about which the upper boom rotates relative to the lower boom.

Lower boom (10)

The structural member attached to a turntable or base, which supports the upper boom.

Lower boom insulating insert (11)

The part of the lower boom made of high dielectric strength material (usually fibreglass reinforced plastic or equivalent).

Lower boom cylinder (12)

The hydraulic cylinder which articulates the lower boom.

Lower boom pin (13)

The horizontal pin about which the lower boom is raised and lowered relative to the turntable.

Turntable (14)

The rotating base of the aerial device that supports the booms.

Pedestal (15)

The stationary base of the aerial device that supports the turntable.

Lower controls (16)

The controls on the vehicle, turntable or pedestal, designed for the movement functions of the aerial device.

Outriggers (17)

The structural members which, when properly extended or deployed on firm ground, assist in stabilizing the mobile unit.

Outrigger controls (18)

The controls for operating the outriggers.

Stabilizers (19)

A means to assist in stabilizing the chassis such as outriggers, torsion bars and spring lock-outs.

Jib (20)

An auxiliary arm at the upper boom tip to support loads.

Liner (21)

Material so formed as to fit inside a platform, or similar support, at the upper boom tip which may modify the electrical properties of the platform.

NOTE - Liners may be fully insulating or conductive.

SECTION 2 - TECHNICAL CHARACTERISTICS

3 Special technical characteristics

3.1 *Dimensions*

The dimensions defined in 2.2 and in Figure H1 of Appendix H shall be supplied.

3.2 *Special devices to ensure safety*

Aerial devices for live working shall be equipped with the following appliances.

3.2.1 *Stabilization of buckets*

The stabilization of buckets shall be ensured either by a mechanical system (e.g., rods, cables and/or chains) or by a hydraulic system, to prevent overturning.

When the stabilization of the bucket(s) is ensured by a mechanical system, another independent means shall be provided.

If the stabilization of the bucket(s) is ensured by hydraulic systems, it shall have locking alves (see ISO 1219).

A safety system shall be provided to separate the stabilization of the bucket from the stabilization of the jib while it is carrying a load. But, when the stabilization of the jib is combined with the stabilization of the bucket, the requirements of 10.4 shall be fulfilled.

NOTE - This standard does not consider the requirements concerning buckets that are tilting or can be positioned in an attitude other than with the bottom horizontal. In some cases the device is used with the bucket tilted. This item is under consideration.

3.2.2 *Personnel safety attachments*

A means shall be provided to permit attaching personnel safety strap(s) or lanyard(s) to the boom. The attachment point shall provide a capacity equivalent to the strength under impact (fall) of the safety strap(s) and/or lanyard(s) for the personnel capacity of the bucket.

3.2.3 *Controls*

3.2.3.1 *Double action of the controls at the bucket*

In order to avoid any untimely actuating of a control at the bucket, the use of an unlocking device shall precede the use of the control itself and shall be maintained simultaneously during the use of controls.

3.2.3.2 *Emergency stop*

A device at the platform shall be provided to enable the operator to immediately stop operation of the function if that control becomes ineffective or uncontrollable.

3.2.3.3 *Control panels*

Aerial devices for live working shall have at least two control panels, one at the bucket and another near the turntable. The lower control panel shall take priority over the upper control panel except for control of the jibs and other functions. In particular, a control at the bucket which becomes activated shall under no circumstances prevent the control panel near the turntable from functioning normally. The boom position controls and their unlocking devices shall return to their neutral position and stop movement when released by the operator. Controls shall be plainly identified as to their function and protected from damage and inadvertent activation.

NOTES

1 Based on the design and type of aerial device and the control panel arrangement employed, all controls should move in a direction that corresponds to the movement function they control.

2 Handles of operating levers of multiple handle controls should each have a distinctive hand grip area shape. The suggested shape and order or position for the controls is shown in Figure H3 of Appendix H.

3.2.3.4 *Control of outriggers*

The hydraulic circuit shall be designed so that power cannot be sent at the same time to the outriggers and to the mobile (operating controls, etc.) parts (for example: electric interlocking hydraulic selector valves, shut off valves, etc.). The controls shall be located so that the operator can see the outrigger being operated. The controls shall be guarded against inadvertent activation.

3.2.3.5 *Autotest of electronic and numeric controls*

A permanent test process shall be provided in the case of electronic and numeric controls to verify that control and action correspond.

3.2.4 *Auxiliary power system*

If the main source of power breaks down, all movements shall stop. There shall be an emergency source of power providing at least rotation of the turret, as well as lifting and descent of the bucket. This emergency system shall be operated from the vehicle chassis and its operation should also be possible from the bucket.

3.2.5 *Rotation of the turntable*

Rotation requirements shall be specified by the customer.

3.2.6 *Communication*

Communication shall be established between bucket and ground locations, including lower control panel. In the case of visual or audible communication, a clear path shall satisfy this requirement.

NOTE - A well-defined system of communication may be used. When a transmitter-receiver system is employed, it should be so equipped that verification of proper operation is possible.

3.3 *Other characteristics*

Hydraulic insulating hoses shall not only comply with 9.1.2, 9.3 and 9.4 but also comply with ISO 6605.

4 Particular electrical characteristics

4.1 *Earthing*

All mobile units shall be equipped with earthing attachment point(s) capable of carrying induced currents.

NOTE - According to the network on which the mobile unit will be employed, the earthing attachment point(s) should be capable of carrying the estimated fault current as specified by the user. Personnel (particularly those on the ground) should be instructed in the safe working procedure for access to the mobile unit under operational conditions (see Appendix K, User's guide.)

4.2 *Electrostatic discharge protection of metal components*

Metal parts for which insulation is not functionally necessary should not be insulated.

NOTE - For an aerial device which has an insulating lower boom insert, the conductive elbow should be electrically discharged before being touched.

4.3 *Corona effect*

4.3.1 *Equipotential connection between conducting parts which are not insulated from each other*

All conducting parts which are not insulated from each other shall be electrically connected together, either by the nature of their assembly or by an equipotential braid.

In particular, it is essential that the ends of all hydraulic hoses shall be electrically interconnected (for an example of a layout, see Appendix J - Figure J1). Suitable access should be provided to check the electrical connections inside the boom.

4.3.2 *Guard electrode*

No damage due to corona effects shall occur at the rated voltage of the aerial device. If necessary, guard electrodes (grading rings) shall be installed to prevent any corona effect so that no parts (hoses, rods, etc.) are damaged (see Appendix J - Figure J2).

Notes

1 Discharges occurring inside the boom, rods, tubes, hoses, etc. may not be visible. If damaging corona is not detected at rated voltage(s), the guard electrode (grading ring) may still be required to minimize electrical stresses on the materials involved and prevent sparkovers (flashovers) during power frequency and switching surge withstand tests, and during use. Corona discharge effects may be determined using partial discharge measurement techniques. See in particular Clause 1, and 3.2 and 4.1 of IEC 270.

2 The full implementation of IEC 270 in this standard on aerial devices with insulating booms is under consideration, since it is impossible to establish acceptable corona levels due to the wide variety of organic insulating materials and systems in use.

4.3.3 *Non-visible conductive parts*

For all conductive parts fixed to or into the insulating section(s), it shall be made apparent that they are conductive. Where this is not technically possible, the outside of the insulating section shall be clearly marked to indicate that a conductive item is included. This marking should be blue.

4.4 *Bonding equipment*

4.4.1 *Bonding cable*

The cable used to bond the bucket to live parts should be able to withstand the aerial device power frequency charging (capacitive) current during 1 h ± 1 min without heating (tolerances 30 °C). This current value shall be determined during the test(s) at the rated voltage and at twice the rated voltage. The values shall be furnished with the aerial device and after each complete re-test in accordance with 8.5.1.1. The cable shall, as a minimum, withstand a current equal to the current measured at twice the rated voltage.

NOTE - A small bonding cable may be destroyed by a fault in the electrical insulating parts of the aerial device.

4.4.2 *Equipotential bonding*

All articulated parts and rotating parts of the aerial device shall be bonded. Example: conductive brush on bearing turntable, jumpers at elbow.

NOTE - These bondings are useful to protect balls, "O" rings, etc., against the effect of leakage currents.

4.5 *Monitoring of leakage current*

Such a device is provided at the request of the customer. If this device is provided, it shall comply with the details given in Appendix C - Figure C5.

NOTES

1 The current electrical circuit should be designed so that it is not damaged due to surges produced by make or break of contact.

2 Periodic tests or work methods. Monitoring may be used for test purposes and when bare hand work is undertaken.

SECTION 3 - TYPE TESTS

5 General

In order to show compliance with this standard, the manufacturer shall provide evidence that the following tests have been carried out successfully.

6 Visual inspection and dimensional check

6.1 *Visual inspection*

Each aerial device component to be tested in accordance with this section shall be visually inspected to check for manufacturing defects and correct functioning.

6.2 *Dimensional check*

Each aerial device component to be tested in accordance with this section shall be checked by measurement to ensure that it complies with the dimensions stated by the manufacturer.

7 Dye penetration test of insulating foam-filled structures

Five test pieces, each 100 mm long, and cut from a different foam-filled structure, shall be completely immersed in a container of 0,1 % by volume or fuchsine/distilled water solution, and this system placed in a vacuum chamber which is then evacuated to less than 6 500 Pa. The test pieces shall remain for 1 h in the dye solution after which the vacuum is released and the test pieces removed.

In order to avoid fuchsine spreading from the sample ends during cutting, it is necessary to dry the test pieces for 24 h in ambient air before cutting them.

After drying, the test pieces are cut 10 mm from each end. The new test pieces thus obtained are then split lengthways. They shall be free from any fuchsine dye penetration.

8 Electrical tests

Electrical tests specified herein are carried out at power frequency.

NOTE - D.C. tests are under consideration.

8.1 *Electrical tests before and after exposure to humidity for the boom, rods, hoses, optical fibre cables and hollow tubes*

These tests are carried out in order to verify the ability of the products to withstand:

- electrical stress before exposure to humidity;
- electrical stress after exposure to humidity;
- electrical stress after infliction of a gash (hoses and optical cables only).

8.1.1 *Boom*

8.1.1.1 *General test conditions*

Before electrical testing, each test piece shall be prepared by cleaning with a trifluorotrichlorethane solution ($CF_2\,Cl\,CFCl_2$) and then dried in air for 15 min.

These tests are carried out on three test pieces, each 300 mm long, which are cut from the boom in such a way as to avoid the use of material within 100 mm of an end.

The ends of these test pieces shall be covered with conductive adhesive tape before each electrical test. At the time of conditioning in a humid atmosphere, this conductive tape shall be removed.

Conditioning in a humid atmosphere is carried out in accordance with IEC 212.

The test location shall be at the standard atmospheric conditions given in Table I of IEC 212, i.e. with a temperature range from 18 °C to 28 °C.

The test arrangement is shown in Figures A1 through A5 of Appendix A. The measuring equipment shall be at least 2 m from the high voltage (HV) electrode. The measuring leads, shunt and optional protective gap shall be shielded and earthed. The test piece shall be mounted approximately 1 m above the ground on an insulating support. A voltage of 100 kV r.m.s. at power frequency is applied between the electrodes, in accordance with IEC 60 and the current passing through the test piece is measured (the guard electrode, on the earth (ground) side, is directly connected to earth).

The specified acceptable current values are given in r.m.s. values. The phase difference between current and voltage is measured as follows:

- current (earth end) by passing it through a known impedance (lower than 10 000 Ω);
- voltage (line end) by means of an appropriate divider.

During the tests there shall be no sign of flashover or puncture of any of the test pieces.

8.1.1.2 *Test before exposure to humidity*

After at least 24 h in the ambient atmosphere of the test area, the current I_1 is measured at an a.c. voltage of 100 kV r.m.s. at power frequency applied between the electrodes for 1 min. The maximum current and the phase angle φ_1 between current and voltage are recorded.

8.1.1.3 *Test after exposure to humidity*

The specimens are placed in a chamber and subjected to the following conditioning:

168 h/23 °C/93 % r.h. according to Table I of IEC 212.

At the end of this period, the test pieces shall remain in an atmosphere of 93 % relative humidity and be tested upon return to the ambient temperature of the test area. After the test pieces have been lightly wiped with a dry cotton cloth, the current I_2 and phase angle φ_2 are measured under the same conditions as I_1 and φ_1.

The test piece shall be located in the same position in relation to earth; the high-potential end of the test piece shall be the same for both tests.

8.1.1.4 *Test results*

The current I_1 measured shall not exceed 5 nA/mm^2 (for this ratio, the whole surface of the measuring electrode shall be taken). See Figure A2 of Appendix A.

The phase angle φ_1 shall be higher than 80°. After exposure to humidity, the current I_2 shall be lower than twice I_1 and the phase angle φ_2 higher than 50°.

8.1.2 *Tubes and rods*

Foam-filled or solid tubes or rods shall comply with IEC 855.

Hollow tubes shall comply with the future IEC publication concerning insulating hollow tubes for electrical purposes.

8.1.3 *Hoses*

Hoses, as applicable, include all flexible components that are of composite or laminated construction.

Hoses in the insulating portion of the boom shall not be wrapped, even with insulating material, because moisture may ingress between the hose and this covering.

Hoses shall comply with Appendix M and with the additional tests specified in 8.1.3.1 and 8.1.3.2 of this standard.

8.1.3.1 *Tests before and after exposure to humidity*

8.1.3.1.1 *General test conditions*

Tests before and after exposure to humidity are the same as those specified in 8.1.1.1, 8.1.1.2 and 8.1.1.3 (in which the word "boom" will be replaced by the word "hoses"). The hoses on test shall be filled with insulating oil recommended by the manufacturer for the aerial device. After the hose has been cut (500 mm minimum length) its ends shall be plugged and sealed (these plugs shall not be removed during conditioning). The test arrangement is shown in Figures A1, A3, A6 and A7 of Appendix A.

8.1.3.1.2 *Test results*

The current I_1 measured shall not exceed 10 µA. The phase angle φ_1 shall be higher than 80°. After exposure to humidity, the current I_2 shall be lower than twice I_1.

If I_2 is greater than twice I_1 but lower than I_1 + 40 µA, the specimen also passes if the phase angle between voltage and the current I_2 is greater than 40°.

In no case shall I_2 be greater than I_1 + 40 µA.

8.1.3.2 *Test after the infliction of a gash on hoses*

This test shall be carried out on three test pieces.

NOTE - A gash of the external surface only may affect its electrical withstand. If the gash were more severe, the hose would burst.

8.1.3.2.1 *Preparation of the test pieces*

The test piece shall be fitted with end fittings, filled with oil at atmospheric pressure and capped. A gash is then inflicted on the surface of the test piece. It consists in cutting the surface until reaching the meshed fibres. The dimensions of the gash shall be:

- length: 20 mm – width: 0,1 mm

For hoses without fibre reinforcement or construction, the gash shall consist of a cut made with a knife, and having a length of 20 mm and a depth equal to 50 % of the wall thickness.

The gash shall be inflicted at a minimum distance of 30 mm from one of the electrodes (see Appendix A, Figure A8).

8.1.3.2.2 *Test procedure*

The test pieces shall be immersed during 24 h under 20 cm of water (conditioning according to IEC 212: 24 h/23 °C/water). The water resistivity shall be 100 Ω.m. The test piece shall be kept horizontal. Then the test specified in 8.1.3 shall be carried out again, but without exposure to humidity.

8.1.3.2.3 *Test results*

No puncture or flashover shall occur. The current is not measured.

8.1.4 *Optical fibre cable*

The optical fibre cable included in the thickness of the boom, tube or rods, shall be tested as indicated in 8.1.1 and 8.1.2.

The optical fibre cable in the insulating portion of the boom shall not be wrapped, even with insulating material, because moisture may ingress between the optical fibre and its covering.

If the optical fibre cables are in the form of an independent optical cable, the following tests shall be applied.

8.1.4.1 *Test before and after exposure to humidity*

8.1.4.1.1 *General test conditions and test before and after exposure to humidity*

These general test conditions are the same as defined in 8.1.1.1, 8.1.1.2 and 8.1.1.3, in which the word "boom" will be replaced by the word "optical cable".

8.1.4.1.2 *Test results*

The current I_1 measured shall not exceed 10 µA. The phase angle φ_1 shall be greater than 80°. After exposure to humidity, the current I_2 shall be lower than twice I_1.

If I_2 is greater than twice I_1 but lower than I_1 + 40 µA, the specimen also passes if the phase angle between voltage and current φ_2 is greater than 40°.

In no case shall I_2 be greater than I_1 + 40 µA. No puncture or flashover shall occur.

8.1.4.2 *Test after the infliction of a gash*

This test shall be carried out on three samples.

NOTE - A gash of the external surface only may affect its electrical withstand. If the gash were more severe, the optical fibre would not function properly.

8.1.4.2.1 *Preparation of the test pieces*

A gash is inflicted on the surface of the test piece. It consists in cutting the surface until reaching the fibre itself. The dimensions of the gash shall be:

- length: 20 mm – width: 0,1 mm

The gash shall be inflicted at a minimum distance of 300 mm from the ends of the optical fibre (see Appendix A, Figure A8).

8.1.4.2.2 *Test procedure*

The test pieces shall be immersed during 24 h under 20 cm of water (conditioning according to IEC 212: 24 h/23 °C/water). The water resistivity shall be 100 Ω.m. The test piece shall be kept horizontal. Then the test specified in 8.1.5.1 and 8.1.5.2 shall be carried out again, but without exposure to humidity.

8.1.4.2.3 *Test results*

No puncture, sparkover or flashover shall occur. Current is not measured.

8.1.5 *Hollow tubes*

Laminated hollow tubes shall not be used. Wet winding fibre reinforced plastic tubes shall not be considered as laminated. Hollow tubes shall not be covered with independent or separate, even insulating, material because moisture could ingress between the tube and this covering.

Hollow tubes shall comply with the future IEC publication concerning insulating hollow tubes for electrical purposes.

8.2 *Dielectric wet test for the boom, rods, hoses, optical fibre cables and hollow tubes*

8.2.1 *General test conditions*

Before dielectric testing, each test piece shall be prepared by cleaning with trifluorotrichlorethane (CF_2 Cl $CFCl_2$) and then dried in air for 15 min.

These tests are carried out on three test pieces, each 1,2 m long, which are cut from booms, tubes, rods, hoses, optical fibre cables and hollow tubes; they shall not use material within 0,1 m of the end.

The electrodes, made with three or four turns of copper or aluminium wire from 2 mm to 4 mm in diameter, shall be 1 000 ± 5 mm apart.

The test location shall be at the standard ambient conditions of IEC 212, with a temperature range of 23 ± 5 °C.

The test arrangement is shown in Figures B1 and B2 of Appendix B. The test piece shall be inclined at an angle of 45°. The voltage of 80 kV r.m.s. at power frequency shall be applied between the electrodes, in accordance with IEC 60, for a period of 1 h.

8.2.2 *Wet conditions*

The wet test is carried out in accordance with the revised wet test procedure described in IEC 60-1 and corresponding to the following revisions:

- average precipitation rate: 1.0 to 1.5 mm/min;
- water resistivity: 100 ± 15 Ω.m.

However, contrary to the requirements of the above-mentioned publication, the test piece shall not be pre-wetted before voltage application; spray and voltage shall be applied simultaneously for 1 h.

8.2.3 *Test results*

The test duration is 1 h and the test is successful if there is:

- no flashover, sparkover or puncture;
- no tracking or erosion on the surface observed without a magnifying glass.

8.3 *Electrical test for oil and devices employing oil*

This test shall be applied to aerial devices that use oil between earth and bucket(s) (controls, tool outlets, etc.).

The method for the determination of the electric strength of insulating oil is described in IEC 156.

Methods for obtaining samples and related specifications are included in IEC 247, 296 and 475.

The values selected shall be in accordance with the requirements of the specific materials employed in the aerial devices and design ratings.

Each individual breakdown voltage obtained during the test shall not be lower than 10 kV. The average of the results shall be greater than 20 kV.

8.4 *Special requirements for hollow booms*

8.4.1 *Sealed hollow boom*

Sealed booms shall be equipped with a reliable system to ensure that the inside is dust and moisture-free.

NOTE - The boom may be filled with inert gas. If so the difference in pressure between the gas and the atmosphere is measured continuously to ensure the efficiency of the sealing. The boom may be fitted with a silica-gel-chemical material ensuring, when blue, that the partial pressure of water is correct. (Usually, the percentage of water is lower than one part per million.)

8.4.2 *Open hollow boom*

If the boom is open, it shall be manufactured in such a way that cleaning, drying and inspection of the inside are possible.

NOTE - An endoscope or any other camera system may be used to permit the internal survey of the boom.

8.5 *Dielectric tests of the aerial devices*

These tests shall be conducted after mechanical tests. The test voltage levels employed depend upon the rated voltage of the aerial device. The aerial device shall be free of damaging corona at its rated voltage.

NOTES

1 The metallic parts of the booms located between the two insulating parts should be earthed before contact by personnel to prevent electrostatic discharge.

2 Corona discharge effects may be determined using partial discharge measurement. See IEC 270, particularly Clause 1, and 3.2.1 and 4.1.

The full implementation of IEC 270 in this standard is beyond its scope, as the level of discharge that may occur, or is permitted, varies among materials and designs which are not specified in detail in this standard.

8.5.1 *Dielectric tests of the complete boom*

The tests shall consist of rated voltage, double-rated voltage and either 10 s withstand or switching surge voltage, as specified in Table I. Applied voltages shall be applied in accordance with IEC 60. If the insulating length of the boom is greater than or equal to 1,0 m, a dielectric surface leakage test of the complete boom shall be conducted.

NOTE - When performed at high voltages, these tests can result in degradation or damage to the boom components, particularly those made from organic insulation.

8.5.1.1 *Boom test at rated voltage, double-rated voltage, and 10 s withstand voltage and switching surge voltage*

Prior to dielectric tests, the resistance of the boom from the lower collector ring (which may be permanent or installed solely for this test) to the lower elbow shall be measured. In addition, the resistance across each of the devices with lower boom and turntable or pedestal insulating insert(s) shall be measured. In all cases, the resistance measured shall be higher than 10 MΩ.

The supporting vehicle with its aerial device is then positioned into the electrical test cell. The specified position of the boom is described in Figures C1 or C2 of Appendix C. The vehicle is earthed. The air clearance to the earthed parts of the test cell (walls and roof) for power frequency test shall be more than the distance D given by the formula:

$$D = \frac{16\,U\sqrt{2}}{3\,400 - U\sqrt{2}} \qquad D \text{ in meters} \qquad U \text{ in kV r.m.s.}$$

U is the power frequency test r.m.s. voltage applied. The dielectric withstand without perceptible heating (tolerance 10 °C) is tested and the leakage current is measured.

Switching surge clearances shall be such that no flashover occurs to the test cell. The voltages for both the rated voltage test and the double rated voltage test are maintained for 1 min. There shall be no sparkover, flashover or puncture during the test. Test voltages and allowable currents are listed in Table I.

Table I - Values for dielectric tests

Rated voltage of the aerial device (Phase-to-ground) kV r.m.s.	Test at rated voltage Maximum allowable ratio Boom current/ test voltage	Test at double rated voltage Maximum allowable ratio Boom current/ test voltage (see notes 1 and 4)	10 s withstand voltage test Test voltage (kV r.m.s.) (see note 4)	Switching surge withstand test (10 positive surges and 10 negative surges) Test voltage (kV peak) (see note 2)
$U_d \leq 200$	1 µA/kV	1 µA/kV	$3\ U_d$	$3\ U_d$ r.m.s. $\sqrt{2}$
$200 < U_d \leq 300$	1 µA/kV	1 µA/kV	$2{,}5\ U_d$	$2{,}5\ U_d$ r.m.s. $\sqrt{2}$
$300 < U_d \leq 462$	1 µA/kV	1 µA/kV	$2{,}2\ U_d$	$2{,}2\ U_d$ r.m.s. $\sqrt{2}$

NOTES

1 The boom leakage current shall not increase during the double rated voltage test.

2 The test wave-form shall have an impulse wave 250 µs/2 500 µs as specified in IEC 60-1.

3 The rated voltage of an aerial device is equal to the maximum use voltage between the top of the boom and the ground. It corresponds to the rated voltage between phase and earth of the system on which live working is carried out.

4 Table I lists typical maximum anticipated overvoltage values for both the momentary (r.m.s.) and switching surge withstand tests. It is up to the user to verify that they are compatible with those that may occur in his networks.

The double-rated voltages and withstand voltages may be adjusted to meet the actual design requirements of (a) given system(s) on which the aerial device will be used. The double-rated voltage test shall be replaced by a test equal to the maximum system (kV max.) plus the maximum system voltage rise on (a) system(s) where the switching surge factor is equal to or less than 2,0 per unit. The withstand voltage test shall be based on the maximum switching surge value of the system.

Example: The double-rated test for a typical operating voltage of 765 kV (maximum of 800 kV) having a maximum switching surge factor of 1,9 per unit may be replaced with a maximum nominal test equal to the maximum system voltage rise.

The maximum percent system voltage rise can be as high as 30 % depending on system conditions. For a 30 % system voltage rise this test would equal kV max. + 30 % (kV max.) i.e. 800 kV + 30 % (800) = 1 040 kV L-L r.m.s. or 600 kV L-G r.m.s. which is 1,3 times the rated voltage.

The momentary withstand test voltage (r.m.s.) for the same system parameters is equal to 1,9 x kV max., 1,9 times the nominal voltage = 878 kV (r.m.s.) or 878 kV L-G (r.m.s.).

The switching surge withstand test for the same system parameters equals $1{,}9 \times 462 \times \sqrt{2} = 1\ 240$ L-G (crest).

Upon agreement between the customer and the manufacturer, different switching surge values may be used. The nameplate and other type test documents shall specify these values.

8.5.1.2 *Dielectric exterior surface leakage test of the complete boom*

The vehicle with its aerial device is placed in the electrical test cell. Electrodes made of adhesive conductive tape 12,7 mm wide are positioned around the upper boom and any external tubes, hoses or pipes at 0,60 m intervals. The upper boom is positioned horizontally at 6 m from the floor. A 90 kV power frequency voltage is applied between each two consecutive electrodes along the length of the boom for an interval of 3 min. There shall be no sparkover, flashover or puncture during the test. No heating of the section of the boom tested shall occur (tolerance 10 °C). Measured current values shall not exceed 0,15 mA for each 0,60 m interval.

NOTE - This test does not measure the surface leakage currents on inside surfaces of the booms or those of rods, hoses, and other components that bridge the insulating interior section of the boom.

Warning: Since the metallic parts (components) above the insulating device may hold an electric charge after this test, they shall be earthed (grounded or discharged) prior to contact by personnel.

8.5.2 *Dielectric test of a lower boom with an insulating insert*

The vehicle is earthed. A 50 kV r.m.s. voltage is applied to the upper end of the insulating insert for 3 min. The upper part of the insert shall be at a distance of more than 1 m from any earthed part (except the lower portion of the lower boom). No flashover, sparkover or puncture and no heating shall occur (tolerance 10 °C).

8.6 *Dielectric test on insulating buckets and liners*

A bucket is not necessarily insulating. It can be made of conductive material or insulating material. In the latter case the bucket can be defined as insulating or not (for example: insulating material with holes). A bucket is defined as insulating if it passes the tests of 8.6.1 and 8.6.2. A liner is defined as insulating if it passes the tests of 8.6.1 and 8.6.2. A bucket passing the tests of 8.6.2 is defined as made of insulating material.

8.6.1 *Puncture test*

The insulating bucket or liner is filled with tap water (resistivity 50 Ω.m maximum) to 0,15 m from the top. The bucket or liner is immersed vertically in an earthed metal tank and a high voltage electrode is placed in the bucket or liner (see Figure C3 of Appendix C).

For buckets, a voltage of 20 kV r.m.s. shall be applied for 1 min ± 5 s.

For liners, a voltage of 50 kV r.m.s. shall be applied for 1 min ± 5 s.

No flashover or puncture shall occur.

8.6.2 *Surface withstand test*

A surface withstand test shall be conducted on the outside of the bucket or liner. Two electrodes are placed 0,30 m apart as shown in Figure C4 of Appendix C. A power frequency voltage of 50 kV r.m.s. shall be applied between the two electrodes and maintained for 1 min ± 5 s. No flashover or puncture shall occur.

NOTE - The value of the leakage current is dictated by the size, and is usually less than 0,5 mA.

8.7 *Jibs*

If the jib is a tube or a rod as described in IEC 855, it shall comply with Clause 8 of that publication. Otherwise it shall be tested as a hollow tube (see 8.1.2).

9 Mechanical tests

9.1 *Fatigue test*

9.1.1 *Fatigue type test on upper boom and lower boom with insulating insert*

On the upper boom and lower boom with an insulating insert, a bending test shall be carried out to simulate the designed operating conditions. The test consists of 10 000 load cycles. The bending forces to be applied shall correspond to the forces resulting from the related loads of the work platform and on the jib.

In case of dispute, the test arrangement shall be the usual operating arrangement, i.e. load applied in bucket and on jib(s).

After this mechanical test, the dielectric tests described in 8.5 shall be carried out.

NOTE - By agreement between the manufacturer and the customer, an equivalent test arrangement may be used; the same bending moment on the boom shall be used, especially for the lower boom test if the boom has an insulating insert, and this shall be noted on the nameplate and instruction manuals.

9.1.2 *Fatigue type test on insulating hoses*

The insulating hoses shall withstand simultaneously cycles of pressure increase and cycles of folding on the part of the hose where the metallic fitting is fixed. The testing device is described in Figure D1 of Appendix D. The hose is linked to a hydraulic tool (shearing machine, press). The whole device is then fixed in order to make an end fixture for the metallic fitting.

Test procedure

The oil pressure shall be raised to the working pressure value provided by the manufacturer in 45 ± 5 s. The hydraulic cycle is defined as follows:

- pressure increase until the specified pressure is obtained in 45 ± 5 s;
- pressure maintained at the specified pressure for 10 ± 5 s;
- decompression in 5 ± 5 s.

The total duration shall be 60 ± 5 s.

For the hydraulic cycle duration lasting 60 ± 5 s, 40 bending cycles are applied to the hose. The insulating hoses shall withstand 1 000 pressure increase cycles and 40 000 bending cycles.

Hydraulic cycle duration test

After these cycles:

1) The pressure is gradually increased to the specified pressure and held for 3 min.

2) The pressure is then gradually increased to 1,5 times the specified pressure and held for 3 min.

3) After this, the pressure is increased until the hose bursts. The increase is between 1,5 and 2,5 MPa/s.

Test results

No defects shall occur when the pressure is kept at the specified pressure and at 1,5 times the rated pressure.

The bursting pressure, after fatigue, shall be greater than or equal to twice the specified pressure.

NOTE - Failure is often indicated by leakage or swelling.

9.2 *Overload test*

9.2.1 *Overload test on boom and jib*

The nominal loads, with an overload factor of 1,5, are applied at the bucket and/or the jib(s). The booms are in the position giving the maximum bending moment. See Figure E1 of Appendix E.

If only a vertical load F_v at the jibs is required, it shall be applied vertically at the end of the jibs, with the overload factor, and with the jibs fully extended, to give a result under the most severe position of the booms.

If both a vertical load F_v and horizontal load F_h are required, the test shall be carried out in the most severe position of the booms and jibs. The force F is applied at the end of the jibs fully extended and with the overload factor. If the jibs can be raised, the most severe raised position shall be determined and tested.

No defect shall occur during this test.

NOTES

1 Max. F_v and F_h are not applicable at the same time (see Figure E1 of Appendix E).

2 In any case, the maximum nominal load in the buckets times the test factor shall be applied vertically in the buckets (e.g. by means of masses).

3 If national regulations require other proof strength or overload factors, these regulations should be followed. However, the resultant load on the complete assembly shall in no case be less than 1,5 times the equivalent load and for a duration of 1 min.

4 The purpose of this test is not to check the stability of the mobile unit but the mechanical withstand of the aerial device.

9.2.2 *Torsion test on boom with bucket(s)*

The torsion test is carried out on the boom in the most severe actual conditions. In the case of one bucket (for one or two persons), the rated load F_{vb} of the bucket is applied at the external edge of the bucket (see Figure E2). In the case of two buckets, the rated load of one bucket is applied at the external edge of only one bucket. Under these test conditions, the requirements of 10.4 shall be fulfilled and no permanent defect or deformation shall occur.

9.3 *Hydrostatic tests*

9.3.1 *Bursting safety factors*

All hydraulic components (except insulating hoses) whose failure could result in free and unrestricted motion of the platform(s) and material lifting device shall have a minimum bursting strength of at least four times the operating pressure for which the system is designed. All other hydraulic components normally rated according to bursting strength only, such as hoses, tubing and fittings, shall have a minimum bursting strength as specified in 9.3.6.

9.3.2 *Hydrostatic tests on insulating hoses*

All hoses, according to type or use, shall be hydrostatically tested to the specified maximum use pressure plus 20 % for a period of not less than 30 s nor more than 60 s with each style or type assembly fitting attached.

There shall be no evidence of leakage, failure or distress to the complete assembly.

9.3.3 *Impulse test on insulating hoses*

9.3.3.1 Impulse testing shall be conducted with new hose assemblies.

The test assemblies shall be impulsed on suitable equipment with the hose bent to minimum bend radius. Hoses of less than 25,4 mm inside diameter shall be bent 180°. Hoses of 25,4 mm inside diameter and over shall be bent 90°.

The test assembly free length of hose measured between couplings shall be computed using the following formula:

$$L\,90 = \frac{\Pi}{2}\,R + 2\,D_O$$

$$L\,180 = \Pi\,R + 2\,D_O$$

where:

$L\,90$ = 90° bend free length

$L\,180$ = 180° bend free length

R = minimum bend radius

D_O = hose outside diameter

The test fluid shall be circulated through the assemblies at the specified temperature with a tolerance of ±3 °C. The impulse rate shall be between 30 and 75 cycles per minute at the operating pressure. Circulation of the test fluid shall be at a rate which will maintain a uniform bore temperature. Cooling or heating of the test chamber shall not be permitted.

The impulse pressure curve shall fall entirely within the shaded area of Figure D2 of Appendix D and shall conform as closely as possible to the curve. Unless failure occurs first, the impulse test shall continue for the specified number of cycles.

NOTE - It is recommended that the test fluid be changed frequently to prevent breakdown.

9.3.3.2 Unless failure occurs first, the impulse test shall continue for the specified number of cycles.

NOTE - It is recommended that the test fluid be changed frequently to prevent breakdown.

9.3.4 *Leakage test on insulating hoses*

9.3.4.1 New hose assemblies on which end fittings have been attached for not longer than 30 days shall be subjected to a hydrostatic pressure equal to 70 % of the specified minimum burst pressure for a period of 5 ± 0,5 min. The pressure is then reduced to zero, after which the 70 % minimum burst pressure shall be reapplied for another 5 ± 0,5 min.

9.3.4.2 There shall be no leakage or evidence of failure. This test is to be considered as a destructive test and the sample shall be subsequently destroyed.

9.3.5 *Change in length test on insulating hoses*

9.3.5.1 Measurements for the determination of elongation or contraction shall be conducted on a previously untested, new hose assembly having at least 300 mm length of free hose between hose couplings. The hose assembly shall be attached to the pressure source and pressurized to the specified maximum working pressure plus 20 % for a period of 30 s, after which time the pressure shall be released. After allowing the hose to restabilize for a period of 30 s following pressure release, reference marks 250 mm apart shall be accurately placed on the hose outer cover, midway between the hose couplings. The hose shall then be repressurized to the above referenced pressure for a period of 30 s, after which time, while the hose is pressurized, the distance between the reference marks shall be measured. This length shall be the final length.

The change in length shall be computed using the following formula:

$$\text{change (in \%)} = \frac{(\text{final length} - \text{original length}) \times 100}{\text{original length}}$$

(−%) change = contraction
(+%) change = elongation

9.3.5.2 The test is considered passed if the change in length of the hose does not exceed 5 % of the original length.

9.3.6 *Burst test on insulating hoses*

Hoses, and/or hose assemblies on which the end fittings have been attached for not longer than 30 days shall be subjected to a hydrostatic pressure increased at a constant rate so as to attain the specified minimum burst pressure within a period of not less than 15 s nor more than 30 s.

The specified minimum burst pressure for insulating hoses shall be twice the rated use pressure for working pressure higher than 30 MPa. The specified minimum burst pressure shall be three times the working pressure for working pressure 30 MPa or less.

There shall be no leakage, hose burst, or indication of failure below the specified minimum burst pressure.

9.3.7 *Cold bend test on insulating hoses*

Hoses and/or hose assemblies shall be subjected to a temperature of –25 °C for 24 h in a straight position. After this time and while still at the specified temperature, the test piece shall be evenly and uniformly bent over a mandrel having a diameter equal to twice the minimum specified bend radius. Bending shall be accomplished within a period of not less than 8 s nor more than 12 s. Hoses of less than 25,4 mm nominal inside diameter shall be bent 180° over the mandrel and hoses of 25,4 mm nominal inside diameter and larger shall be bent 90° over the mandrel.

After bending, the test pieces shall be allowed to reach room temperature, then visually examined for cover cracks and subjected to the leakage test (see 9.3.4). There shall be no cover cracks or leakage.

9.4 *Oil depressurization*

All the hoses and the oil insulating tubes which are situated near or inside the insulating boom on the aerial devices and where the maximum height of the barometric column of oil (when all booms are fully extended) exceeds 11 m shall be equipped with devices which prevent depressurization leading to partial vacuum of oil pressure of 20 kPa and liable to produce electrical breakdowns. The test shall be carried out by simulating a reduction of the oil pressure (by opening a tap or cutting the pipes). When this is realized, the absolute pressure in the hoses or pipes at the top of the boom shall be more than 80 kPa.

NOTE - This pressure is generally measured with a differential manometer. The absolute pressure is obtained by the difference.

As an example, such a device could be a valve preventing gravity from drawing the oil out of the line, added to a vacuum relief valve. If such devices are used, the following test shall be carried out. These valves shall open to atmosphere when the absolute pressure inside the hoses or pipes normally containing oil in an evacuated area is below 80 kPa.

10 Mechanical factors that affect the use of a mobile unit during live working

10.1 *Boom deflection*

Vertical boom deflection is measured between the bucket and the base of the pedestal or pedestal support system, and shall not exceed the value F_{MAX} given by the following formula:

$$F_{MAX} = 1\ \%\ \text{of the height} + 5\ \%\ \text{of the outreach}$$

at the vertical rated load of the boom, the boom being in the position to reach maximum deflection.

When the load is removed, the boom shall come back to the initial position ±10 mm (the platform height) and 5 % of the horizontal reach measured in the test position.

10.2 *Horizontal bucket loading*

The aerial device bucket shall not move more than 200 mm, when a horizontal force of any direction of 400 N is applied per person capacity of the bucket.

10.3 *Bucket creep*

At the rated load, the bucket creep shall not exceed 100 mm after 1 h in the most severe position. The measurement is made vertically between bucket and base of pedestal or pedestal support system.

10.4 *Bucket tilt angle*

The rated bucket load is successively applied to the front, back, right and left edges of the bucket. The angle α shall not exceed 5° for any test (see Figure E3 of Appendix E).

10.5 *Precision of upper controls at the bucket*

The precision of the aerial device controls at the bucket should be such that the operator can approach his work area slowly and safely. Coming from a distance of 1 m, the operator should be able to position the bucket at less than 50 mm from the work area without tilting, or requiring a second use of the controls. This should be done for each of the upper controls.

11 Determination of the flammability for insulating buckets and liners

This test is carried out according to IEC 707. The material shall comply at least with category FV2.

SECTION 4 - SAMPLING AND ROUTINE TESTS

12 Sampling tests

After agreement between the manufacturer and the customer, all the type tests described above, or only part of them, shall be carried out again as sampling tests. They shall be made under the responsibility of the manufacturer who shall make their results available to the customer. The sample size is chosen by agreement between the manufacturer and the customer.

13 Routine tests

The manufacturer shall make available to the customer the results of the tests. In order to show compliance with this specification, the manufacturer shall provide evidence to the customer that the routine tests have been carried out successfully on materials conforming to the following:

- conformity of the constituent materials to those which underwent the type tests;
- consistency of the constituent materials.

NOTE - The customer may request a certificate that this has been done.

13.1 *Visual inspection*

Each aerial device shall be visually inspected to check for manufacturing defects.

13.2 *Operation*

Each aerial device shall be operated to check for correct function and performance.

13.3 *Dielectric tests*

The dielectric tests specified in Table I of 8.5 shall be carried out on each aerial device. The voltage shall be applied to determine that the aerial device complies with 8.5 and that the components, as employed, are suitable for switching surge.

13.4 *Mechanical tests*

The mechanical tests specified in subclause 9.2 shall be carried out on each aerial device.

13.5 *Acoustic emission test method*

Upon agreement between the customer and the manufacturer, acoustic emission testing shall be performed on the aerial device, in particular on the fibre reinforced plastic components, when new and before use, to establish the data needed as a permanent reference to monitor the performance of these components. This method provides a means to check ageing and point out anomalies (see Appendix L).

NOTES

1 Although the test is considered to be primarily applicable to the insulating portion of new booms at this time, it is very useful for detecting mechanical defects in all aerial device components.

2 Modifications to include more detailed acceptable values and data, and techniques for establishing ageing periods are under consideration in relation to Appendix L.

13.6 *Determination of device stability*

Aerial device stability shall be determined using ISO 4305 and ISO 4302. In making the loading evaluation, the loads indicated in 9.2, plus those of personnel during work operations (see 10.1), shall all be simultaneously taken into consideration, in addition to wind.

The rated value of the in-service wind speed shall be noted on the nameplate and included in all aerial device documents.

SECTION 5 - SPECIAL CLAUSES

14 Marking

Each aerial device shall carry at least the marking specified in Figure F1 of Appendix F. The number of buckets that the aerial device is rated and tested for shall be specified, as well as the rated wind speed. The marking shall not affect the performance of insulating parts.

15 Modifications

Before carrying out any modification of any characteristics, during the manufacture of an order, the manufacturer shall obtain the agreement of the customer. Any modifications made by the customer on an accepted aerial device should be approved by the manufacturer.

Modifications may require new type tests, in whole or in part, according to the extent of the modifications.

16 Acceptance tests

See Clause 2 and Appendix G for supplementary guidance.

APPENDIX A
(normative)

Electrical tests before and after exposure to humidity

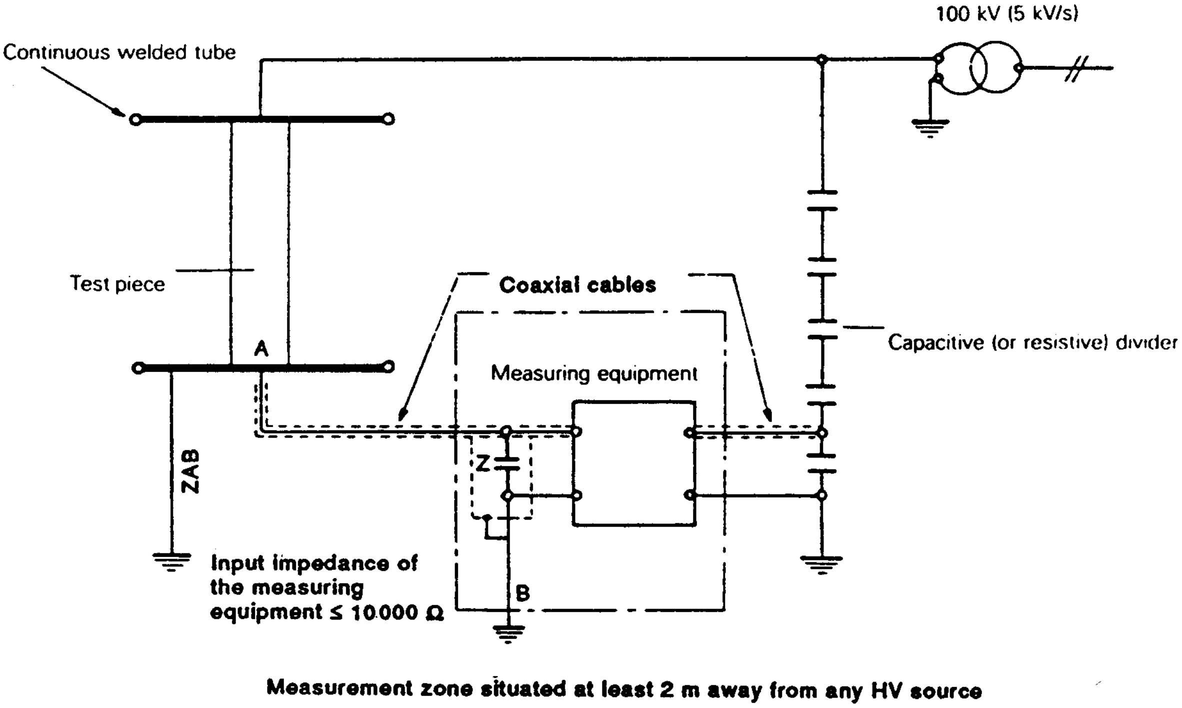
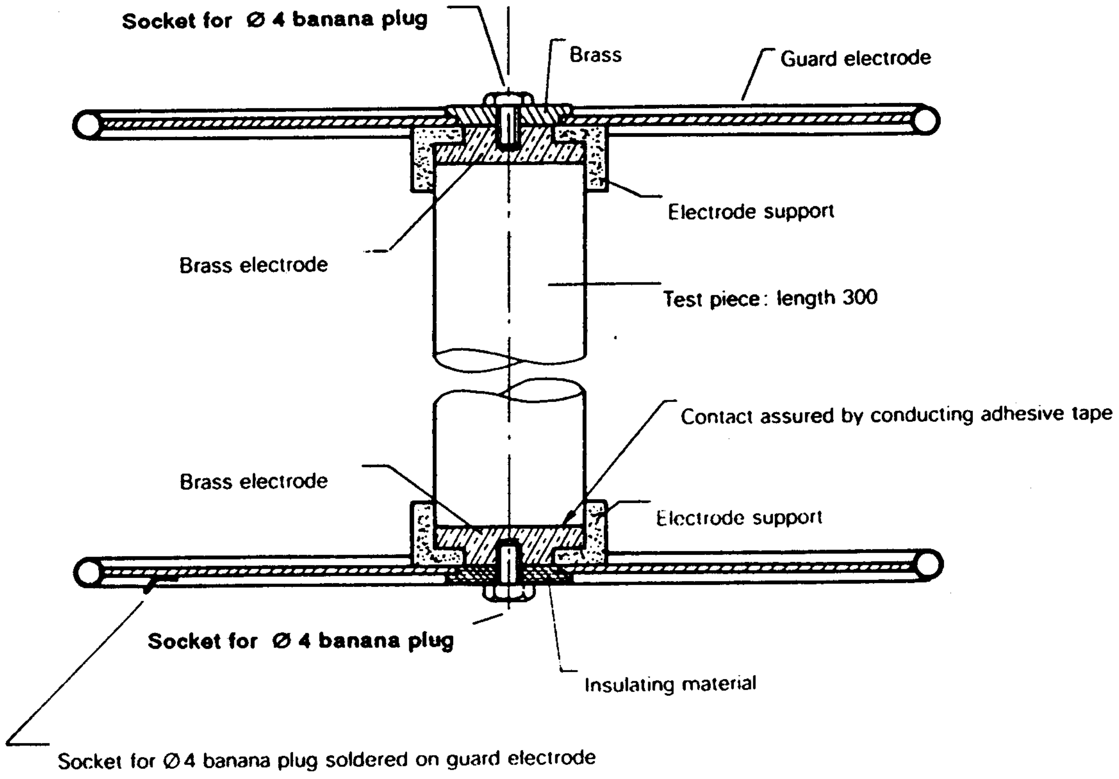
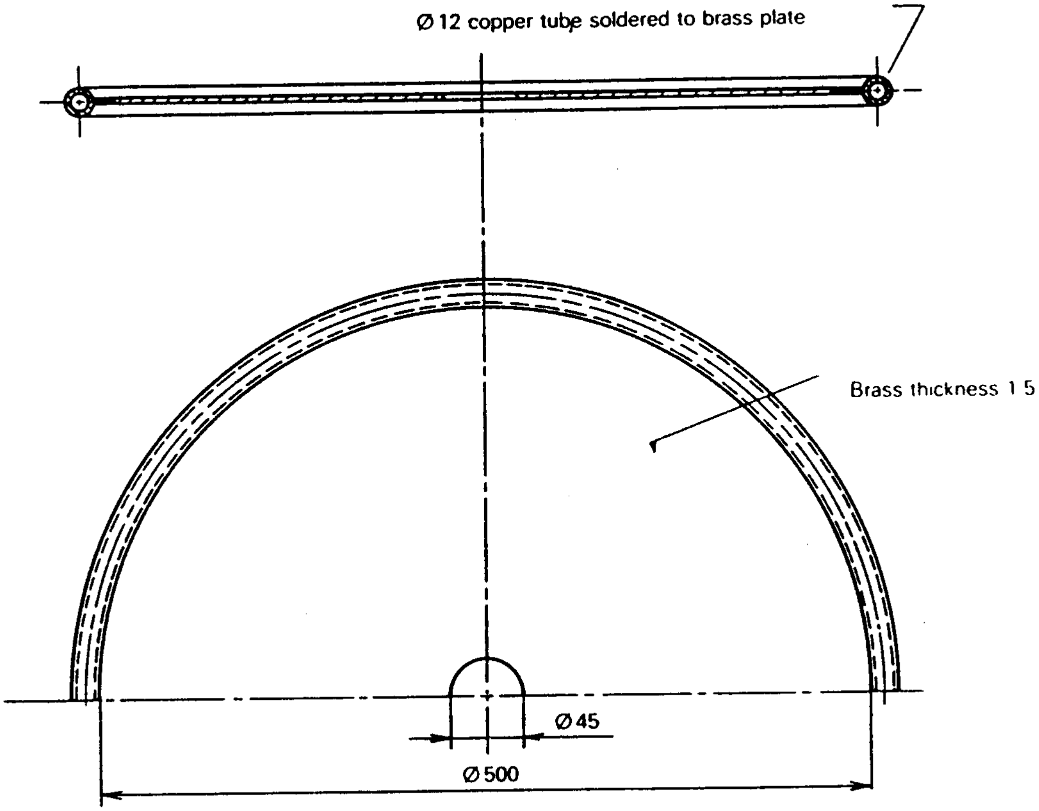

100 kV (5 kV/s)
Continuous welded tube
Test piece
Coaxial cables
Capacitive (or resistive) divider
A
Measuring equipment
Z
ZAB
Input impedance of the measuring equipment ≤ 10 000 Ω
B
Measurement zone situated at least 2 m away from any HV source

Figure A1 - Test arrangement


Socket for Ø 4 banana plug
Brass
Guard electrode
Electrode support
Brass electrode
Test piece: length 300
Contact assured by conducting adhesive tape
Brass electrode
Electrode support
Socket for Ø 4 banana plug
Insulating material
Socket for Ø 4 banana plug soldered on guard electrode

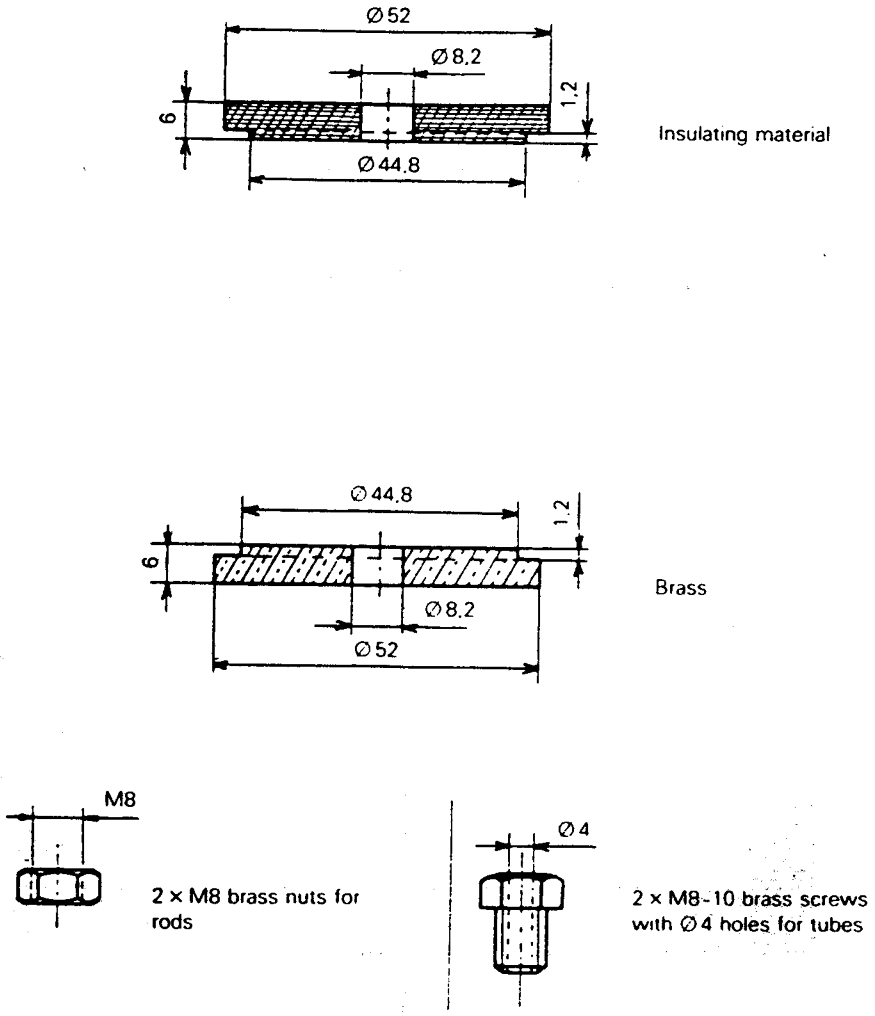
Dimensions in millimetres

Figure A2 - Assembly diagram (normatif)



Dimensions in millimetres

Figure A3 - Constructional drawing for guard electrodes (two required)



Insulating material

Brass

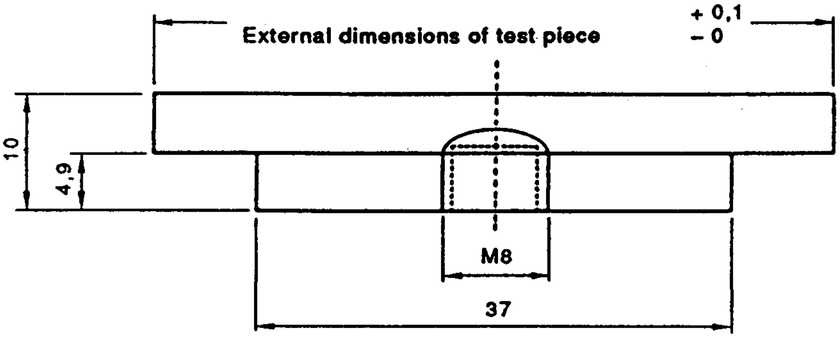
2 × M8 brass nuts for rods

2 × M8-10 brass screws with Ø4 holes for tubes

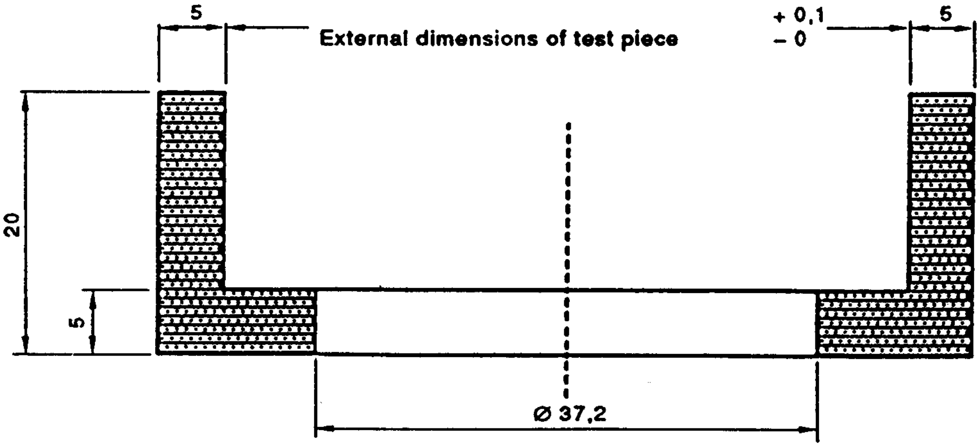
Dimensions in millimetres

Figure A4 - Constructional drawing for guard electrodes - Parts Ⓐ and Ⓑ

2 brass electrodes

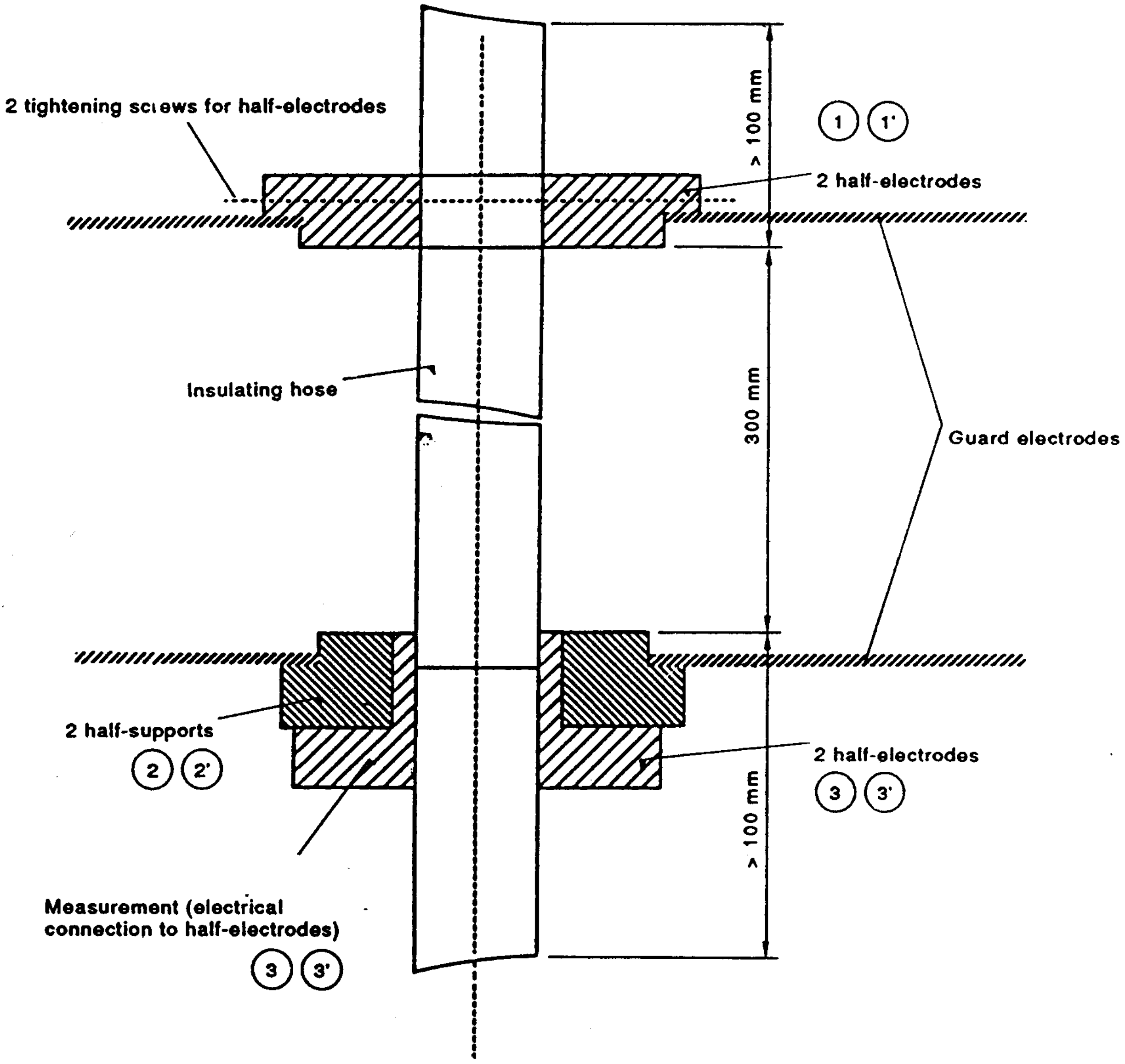


2 insulating supports



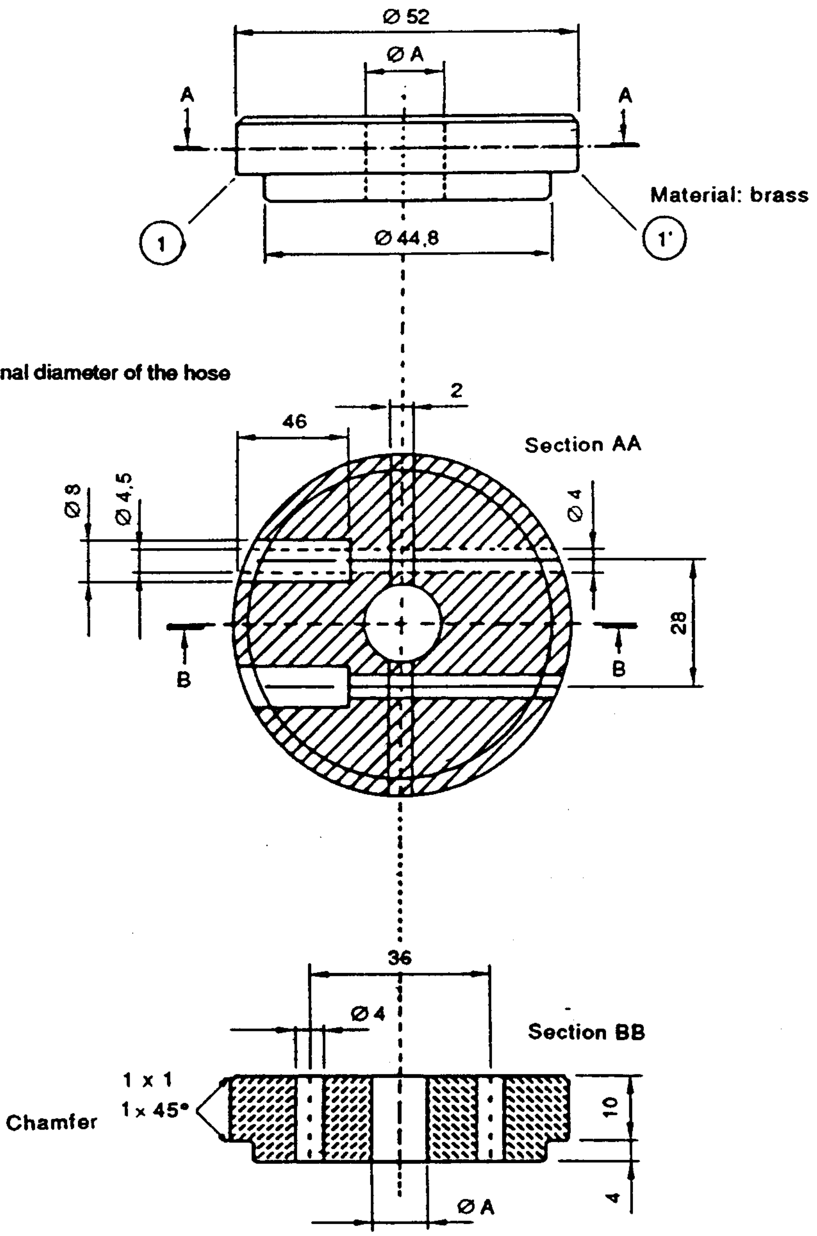
Dimensions in millimetres

Figure A5 - Constructional drawing for guard electrode parts according to test piece section



The definition of the elements 1 - 1', 2 - 2', 3 - 3' is given in Figure A7.

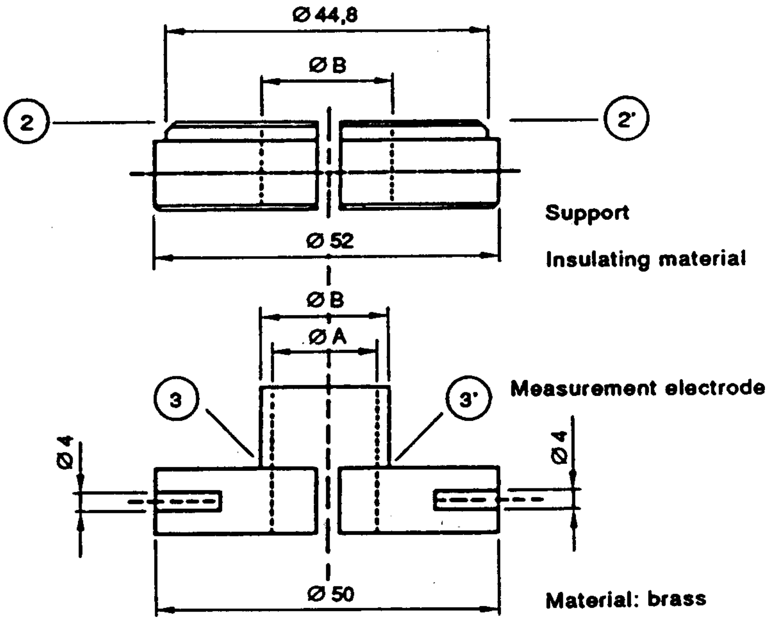
Figure A6 - Assembly diagram for insulating hoses



Ø A = external diameter of the hose

Dimensions in millimetres

Figure A7a - Constructional drawing for guard electrodes accessories for hoses - Parts 1 and 1'



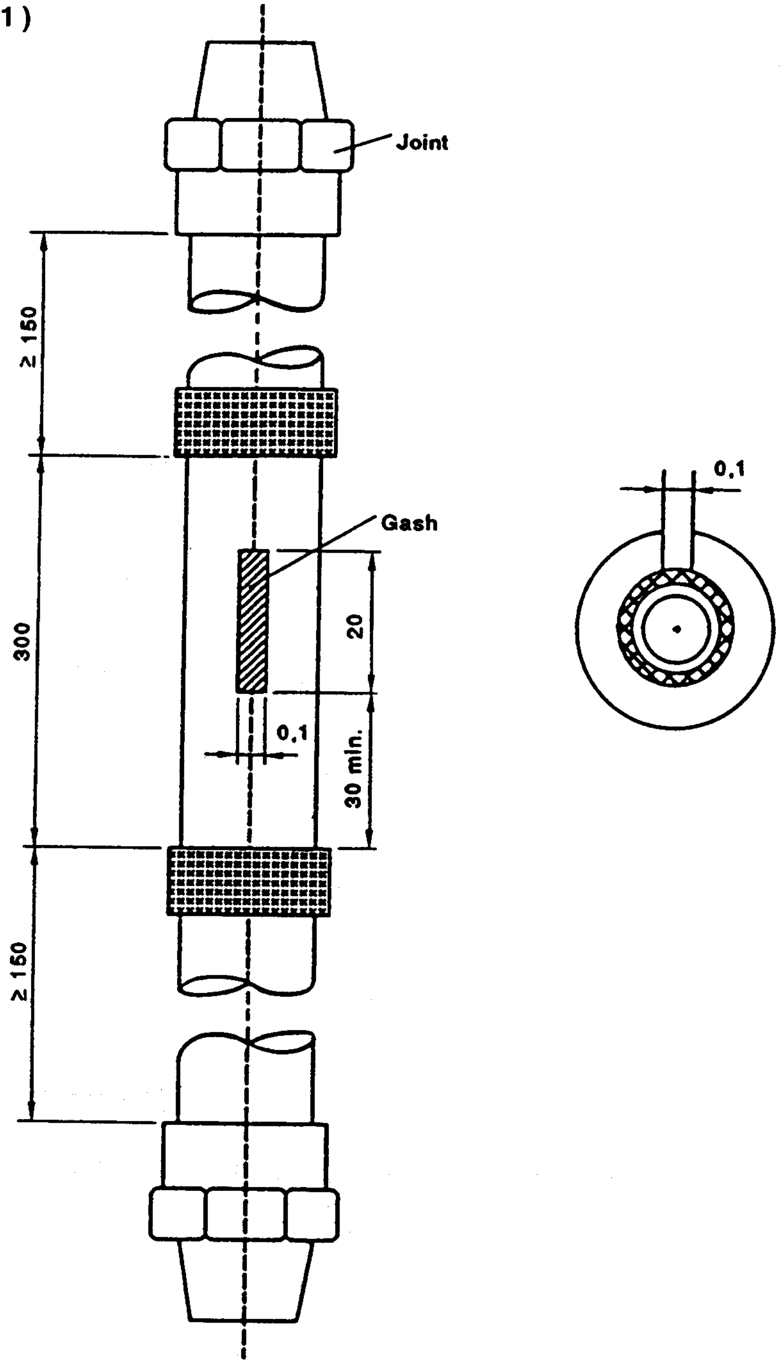
Ø A = external diameter of the hose

Ø B = Ø A + 6

The linking device between parts 2 and 2' is identical with the device between parts 1 and 1' described in Figure A7a.

Dimensions in millimetres

Figure A7b - Constructional drawing of guard electrodes accessories for hoses - Parts 2 - 2' and 3 - 3'



Dimensions in millimetres

Figure A8 - Preparation of specimen for test after the infliction of a gash

APPENDIX B
(normative)

Dielectric wet test

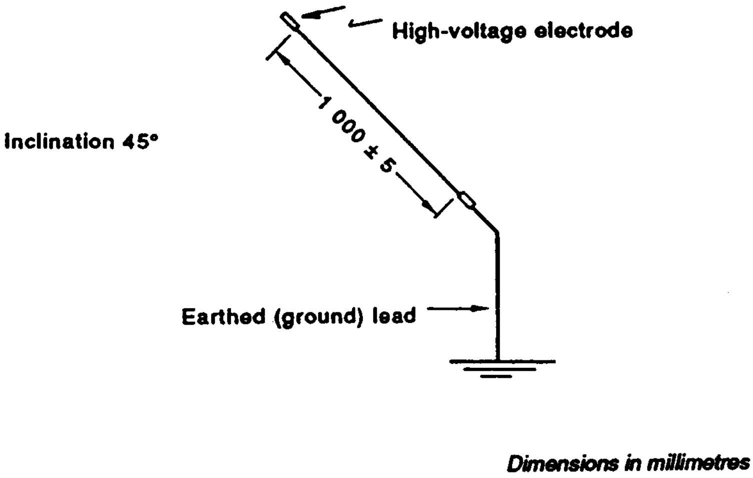


Figure B1 - Typical test arrangement

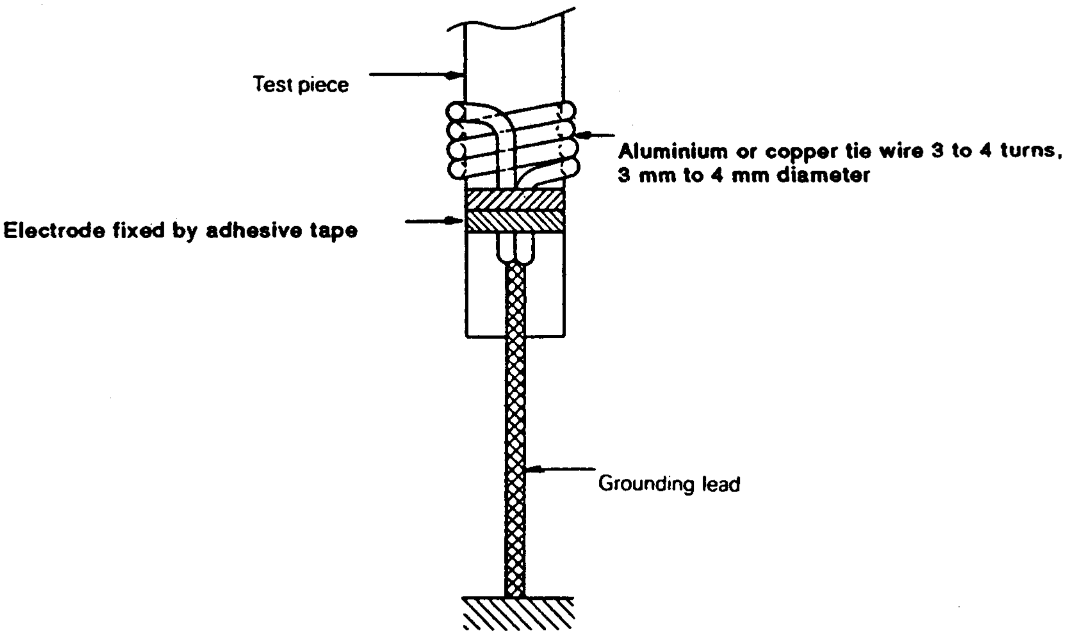
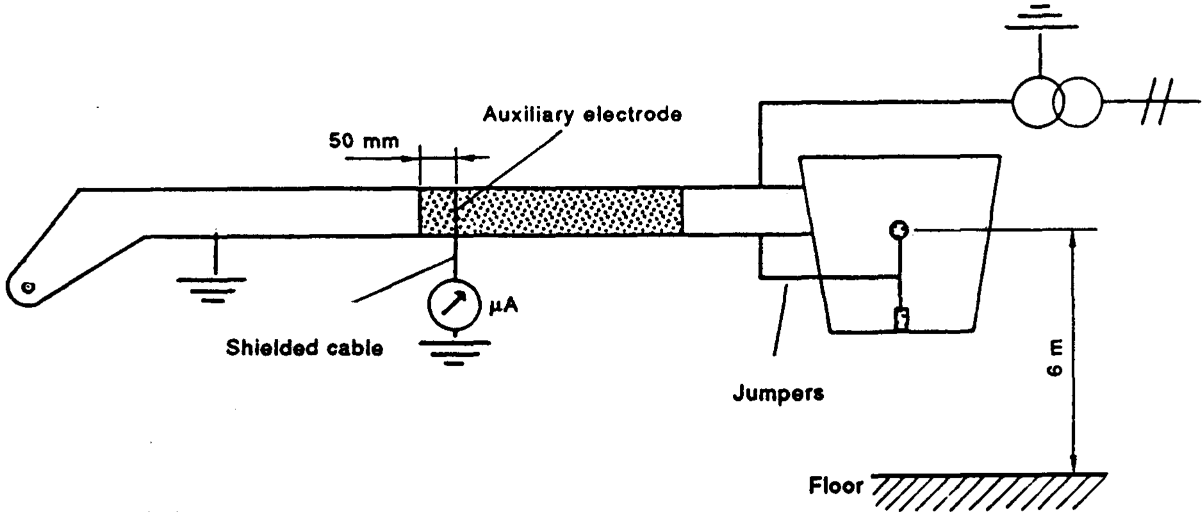

Test piece
Aluminium or copper tie wire 3 to 4 turns,
3 mm to 4 mm diameter
Electrode fixed by adhesive tape
Grounding lead

Figure B2 - Details of electrode arrangement

APPENDIX C
(normative)

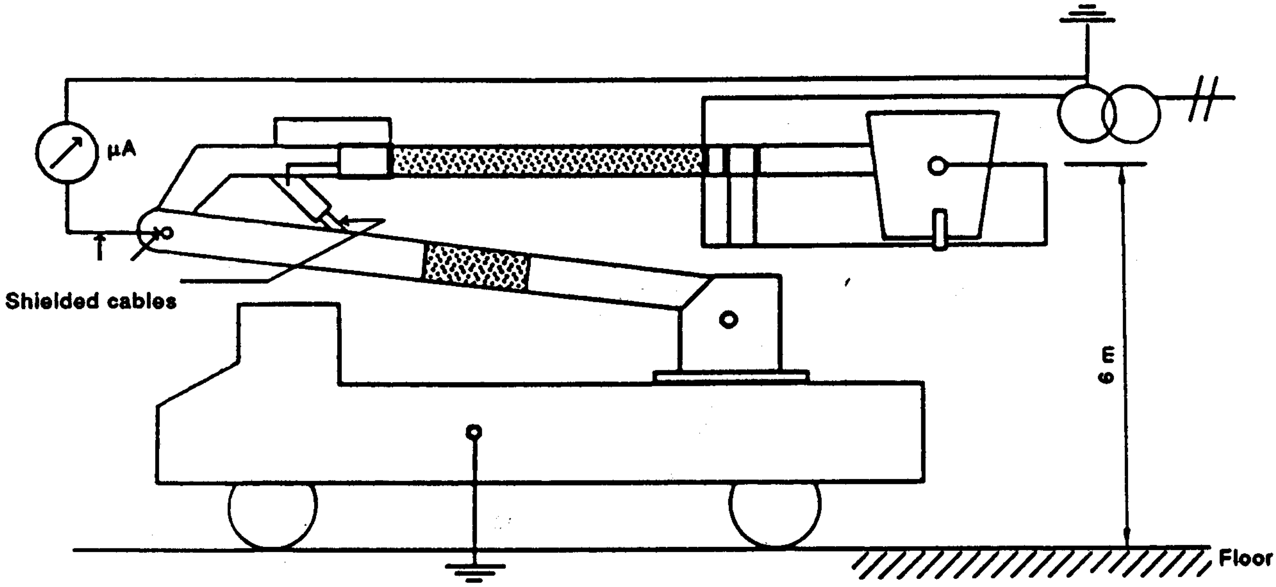
Electrical tests for aerial devices



The metal lower ends of the hoses (if any) shall be reconnected to the auxiliary electrode.

If the rated voltage of the aerial device is more than 200 kV, the boom shall be extended to its maximum vertical height.

Figure C1 - Aerial device with lower boom without insulating insert



If the rated voltage of the aerial device is more than 200 kV, the boom shall be extended to its maximum vertical height.

Figure C2 - Aerial device with lower boom with insulating insert

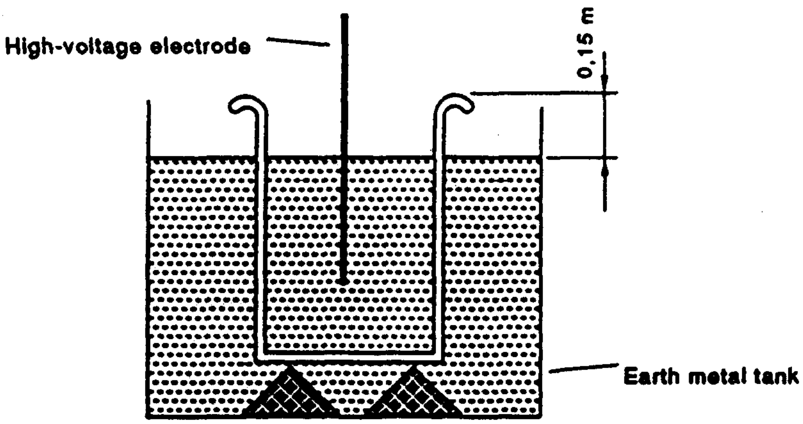


Figure C3 - Puncture test on insulating bucket or liner

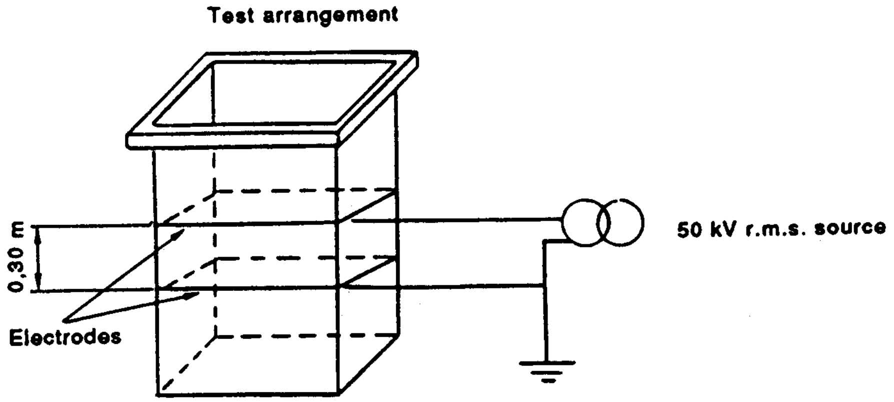
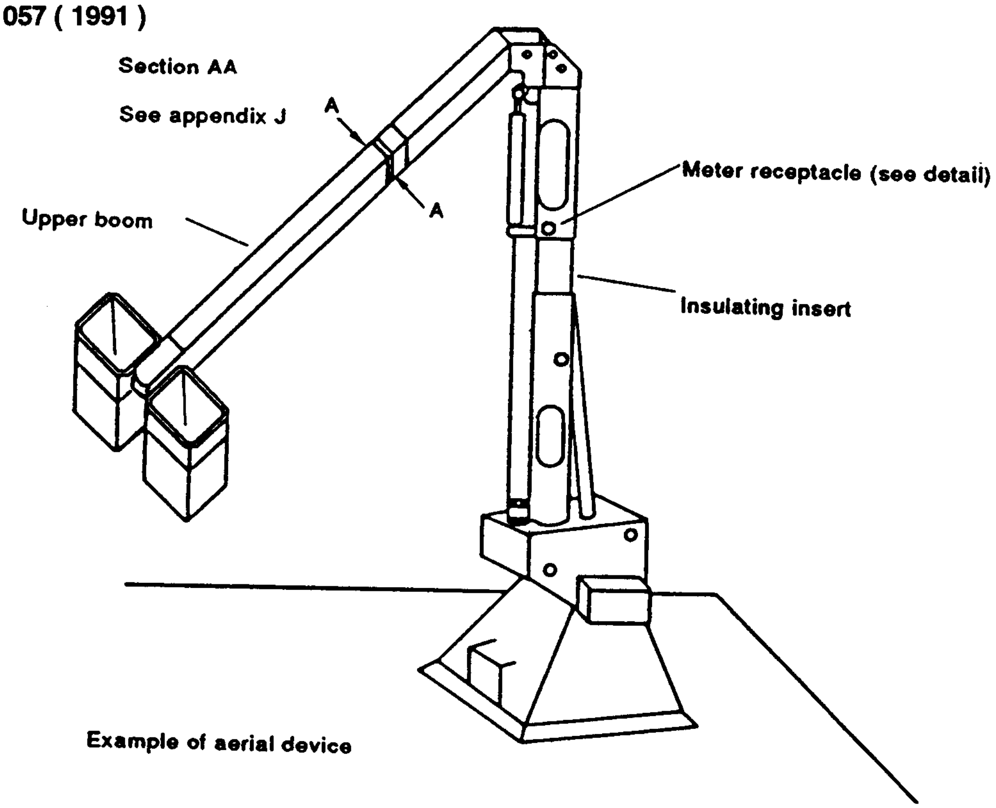
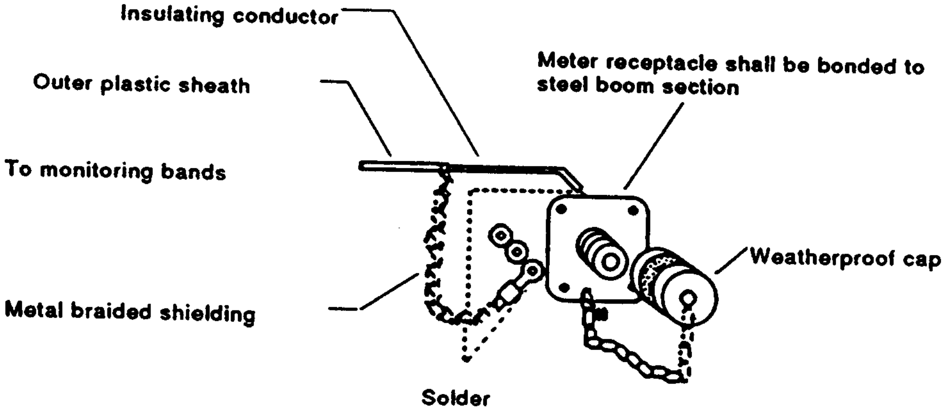


Figure C4 - Surface test on insulating bucket or liner



Example of aerial device



Meter receptacle assembly

Figure C5 - Example of boom current leakage monitoring system

APPENDIX D
(normative)

Fatigue test of insulating hoses

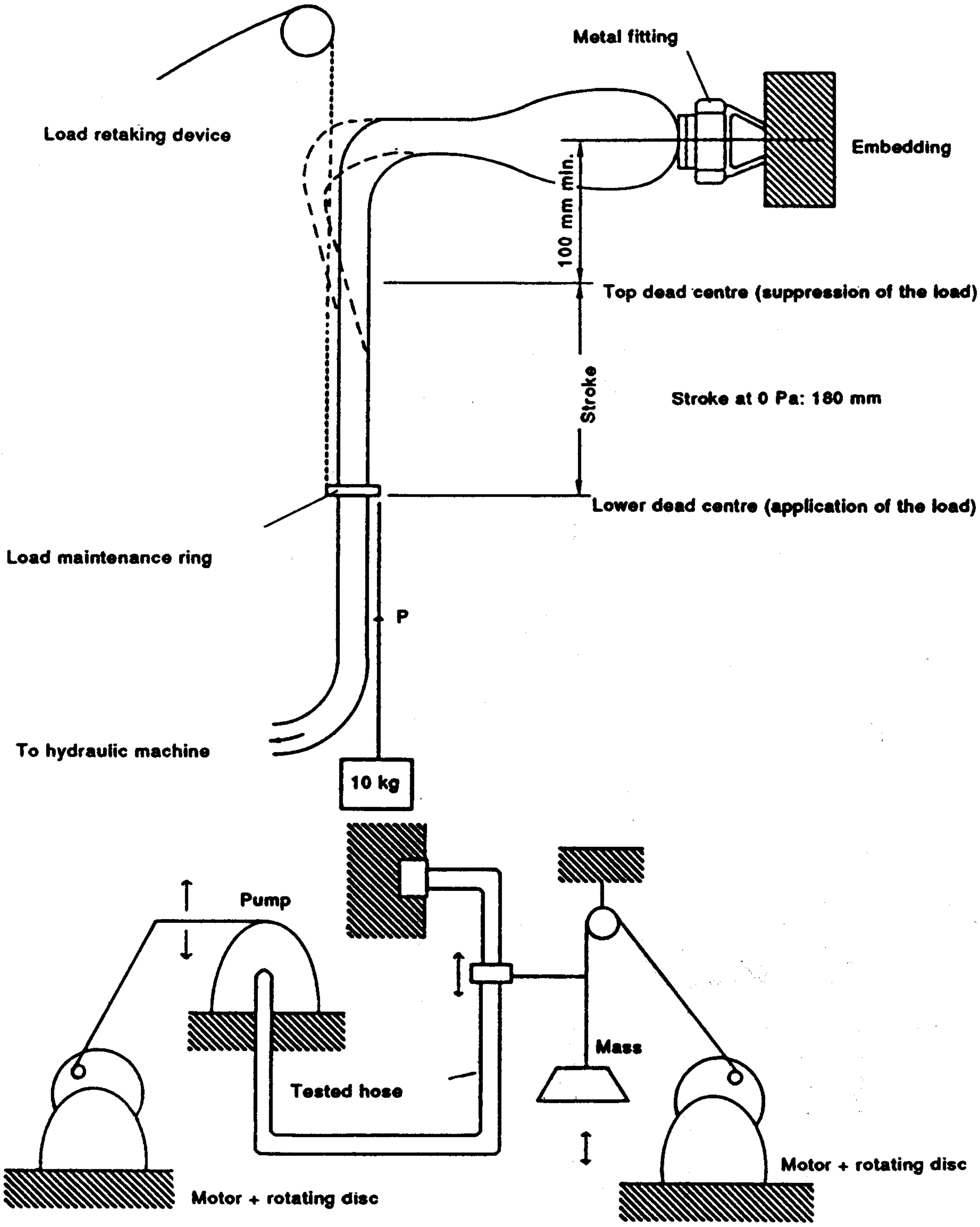
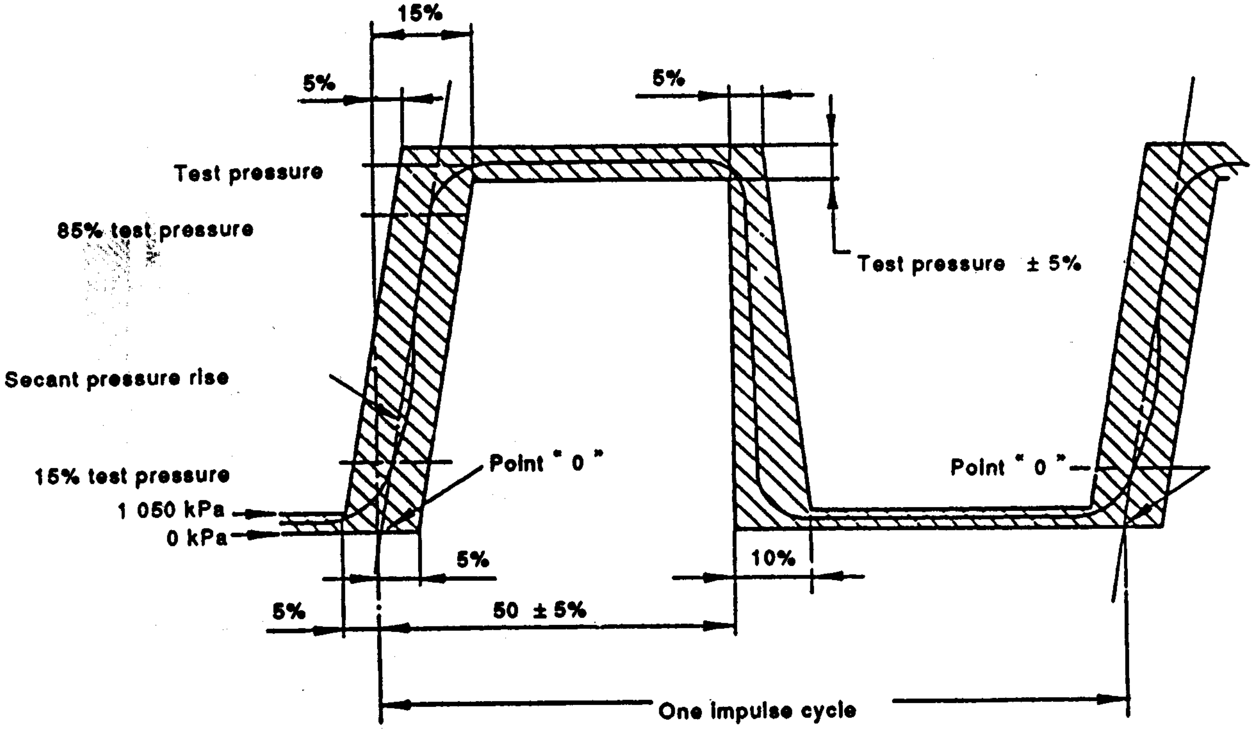


Figure D1 - Testing device



Point «0»

Secant pressure rise - The straight line drawn through two points on the pressure rise curve: one point at 15 % of the test pressure and the other at 85 % of the test pressure.

Cycle rate to be uniform at 30 to 75 CPM

Point "0" - The intersection of the secant pressure rise with 0 pressure.

Pressure rise rate - The slope of the secant pressure rise expressed in kPa per second.

Figure D2 – Pressure impulse cycle on insulating hose

APPENDIX E

Overload test

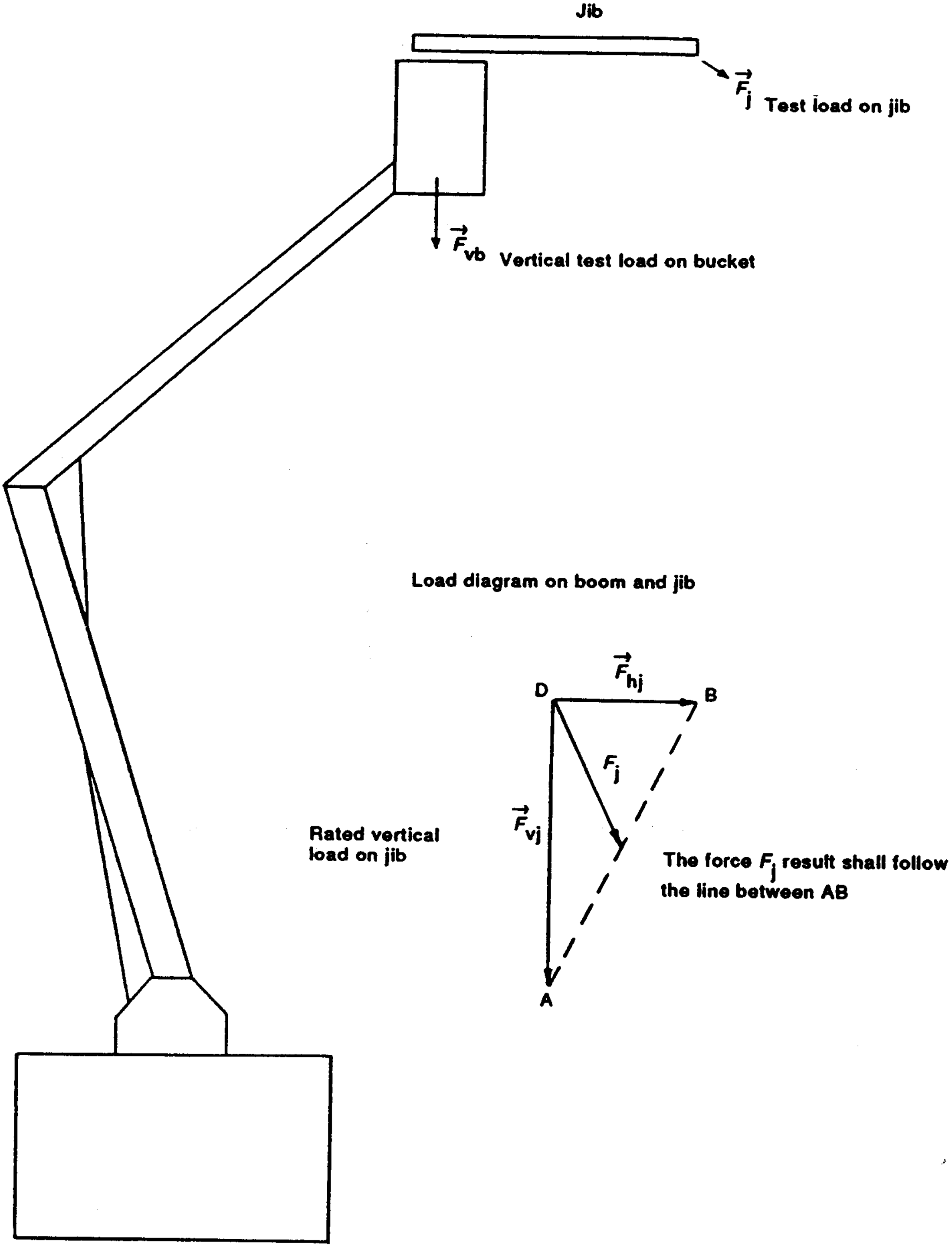

Jib
$\vec{F}_j$ Test load on jib
$\vec{F}_{vb}$ Vertical test load on bucket
Load diagram on boom and jib
D
$\vec{F}_{hj}$
B
F_j
$\vec{F}_{vj}$
Rated vertical load on jib
The force F_j result shall follow the line between AB
A

Figure E1 - Overload test on boom and jib

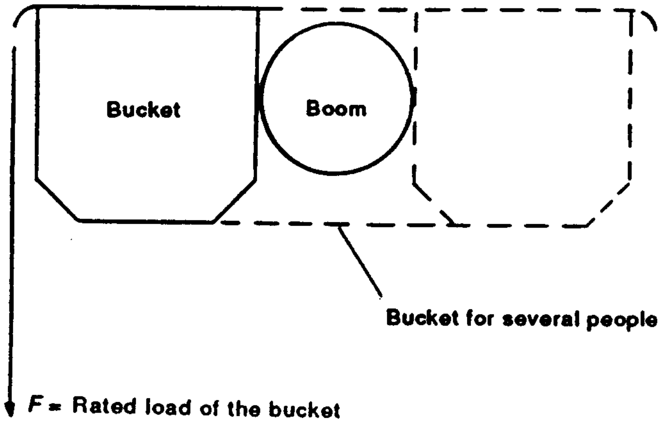


Figure E2 - Torsion test on boom with bucket(s)

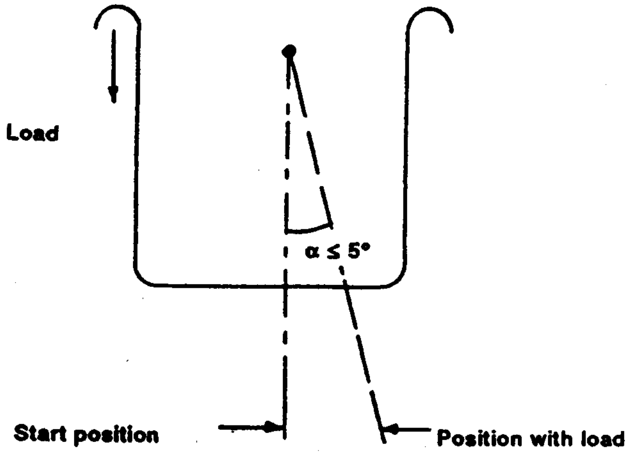


Figure E3 - Bucket tilt angle

APPENDIX F
(normative)

Marking

Type: ______________________ **Serial No. :** ______________________

Platform height : ________________ **Rated voltage :** ____________________

CAPACITY RATING
This aerial device complies with the requirements of IEC Publication 1057.

On a firm and level surface its capacity is:

__________________________ **N per bucket**

__________________________ **N per jib (vertical and horizontal)**

__________________________ **N total (both buckets and jibs)**

Date of acceptance : __________________________

AERIAL DEVICE SYSTEM PRESSURE : ____________________ **MPa**

AERIAL DEVICE MANUFACTURING C° : **CITY, STATE, COUNTRY :**

Installed by : ______________________________________

Figure F1 - Marking

APPENDIX G
(informative)

Acceptance tests

As defined in IEV 151-04-20, an acceptance test is a contractual test to prove to the customer that the device meets certain conditions of its specification. These tests may be carried out on every unit (routine test) or on a sampling of the units (sampling tests).

If a customer indicated in his specification that the device shall meet the IEC specification only, the acceptance tests are those (both routine and sampling) which are specified in this specification.

The customer may, however, if he wishes, ask for additional tests or modify the sampling size but shall include this in his own specification.

The customer may wish to witness the tests, have someone witness them or simply accept the results of the tests as carried out by the manufacturer. He may also specify that the tests be carried out in an independent laboratory of his choice or even in his own laboratory.

Further, the customer may specify additional tests or larger sample sizes when he is purchasing from a new manufacturer because he has experienced problems with a particular manufacturer, or he is purchasing a new product or a new design.

APPENDIX H
(normative)

Specific terms and nomenclature

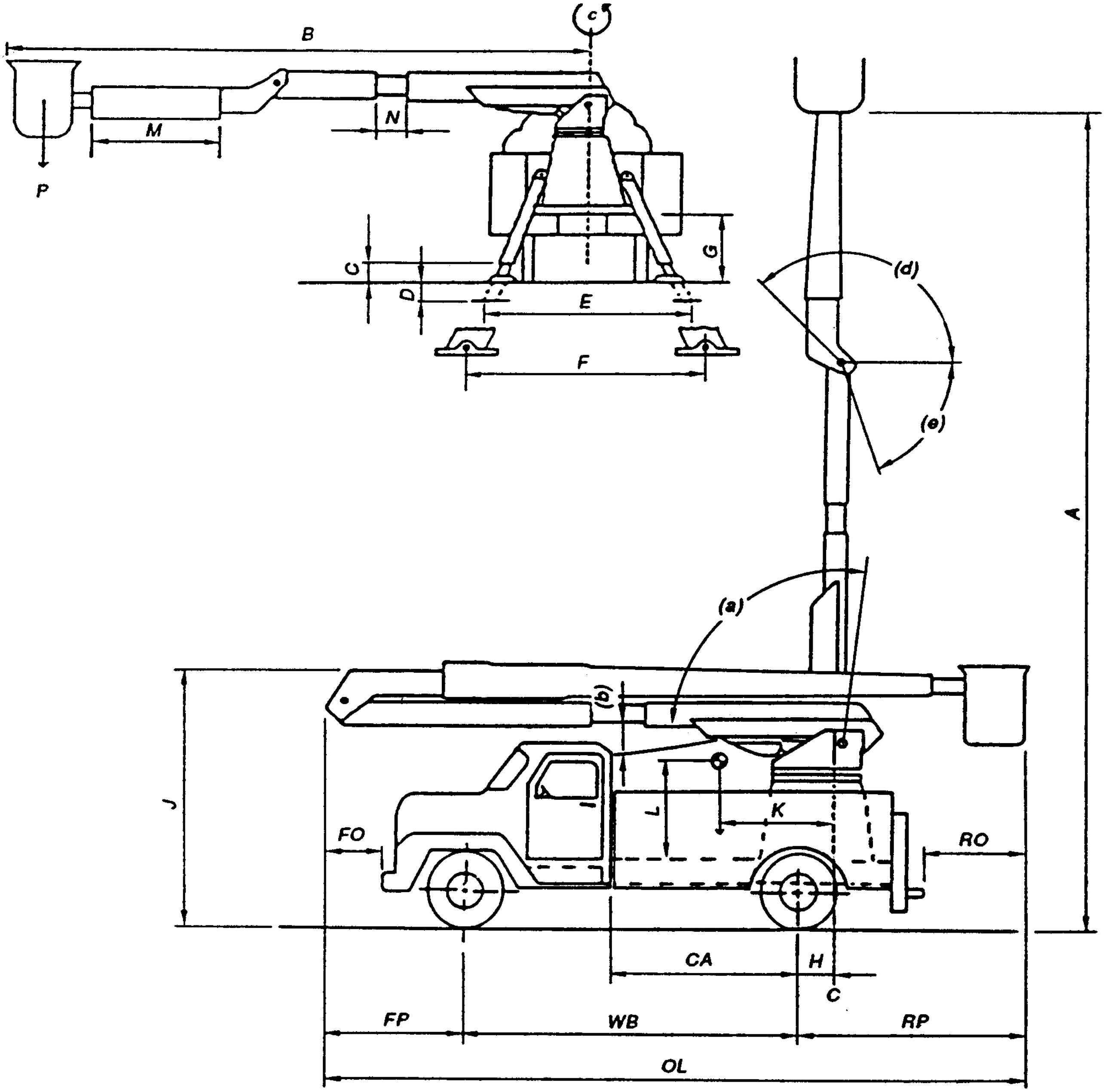


Figure H1 – Specific terms and nomenclature

Platform height (of the mobile unit)	*A*
Horizontal reach	*B*
Outrigger height	*C*
Outrigger penetration (below ground level)	*D*
Outrigger spread (at ground level)	*E*
Outrigger spread (at maximum extension)	*F*
Chassis height	*G*
Wheel base	*WB*
Cab axle dimension	*CA*
Front projection	*FP*
Rear protection	*RP*
Aerial device C.G. (horizontal)	*K*
Front overhang	*FO*
Rear overhang	*RO*
Overall length	*OL*
Aerial device C.G. (vertical)	*L*
Insulation gap (upper boom)	*M*
Insulation gap (lower boom)	*N*
Centre of rotation location	*H*
Travel height (stowed) of the mobile unit	*J*
Rated capacity	*P*
Aerial device weight	*W*
Lower boom travel up	(*a*)
Lower boom travel down	(*b*)
Turntable rotation	(*c*)
Upper boom travel up	(*d*)
Upper boom travel down	(*e*)

Figure H1 - Specific terms

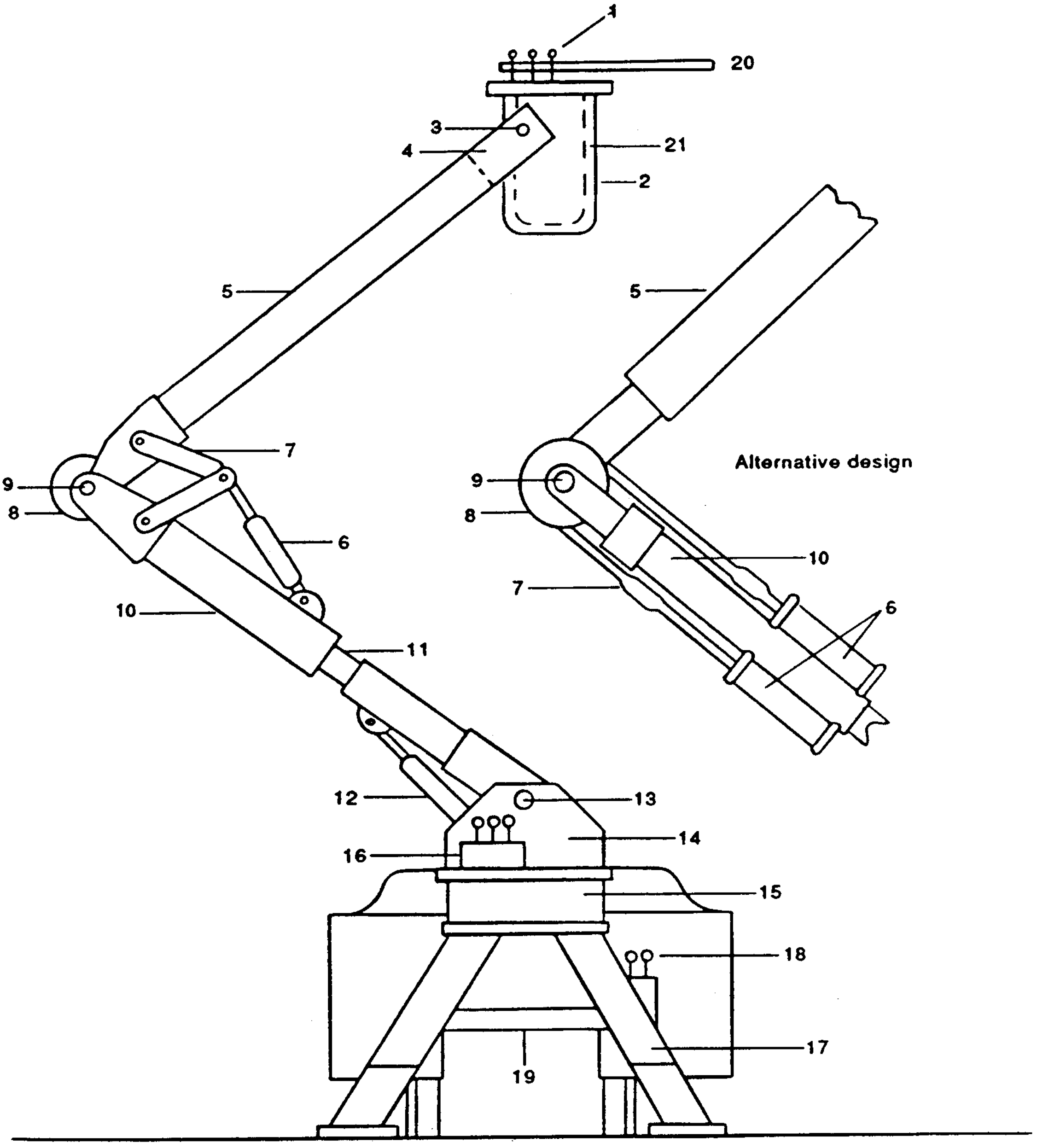


Figure H2 – Nomenclature

1 = Upper bucket controls
2 = Platform
3 = Platform or bucket pin
4 = Upper boom tip
5 = Upper boom
6 = Upper boom cylinder
7 = Upper boom drive mechanism
8 = Elbow
9 = Elbow pin
10 = Lower boom
11 = Lower boom insulator
12 = Lower boom cylinder
13 = Lower boom pin
14 = Turntable
15 = Pedestal
16 = Lower controls
17 = Outriggers
18 = Outrigger controls
19 = Stabilizers
20 = Jibs
21 = Liner

Figure H2 - Nomenclature

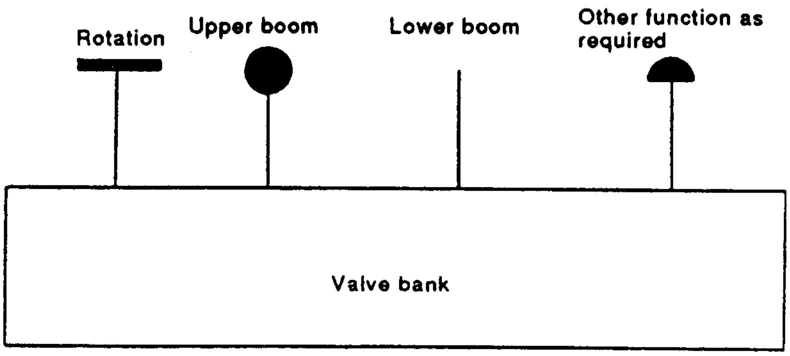


Figure H3 - Example of lever-type control arrangement and shape

APPENDIX J
(informative)

Details of typical boom current monitoring system

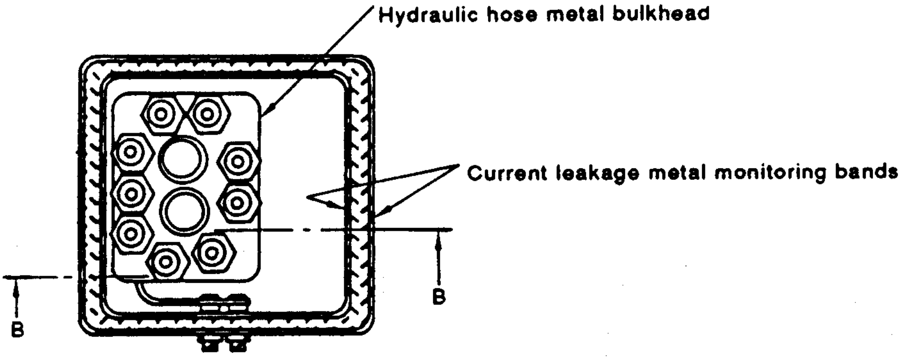
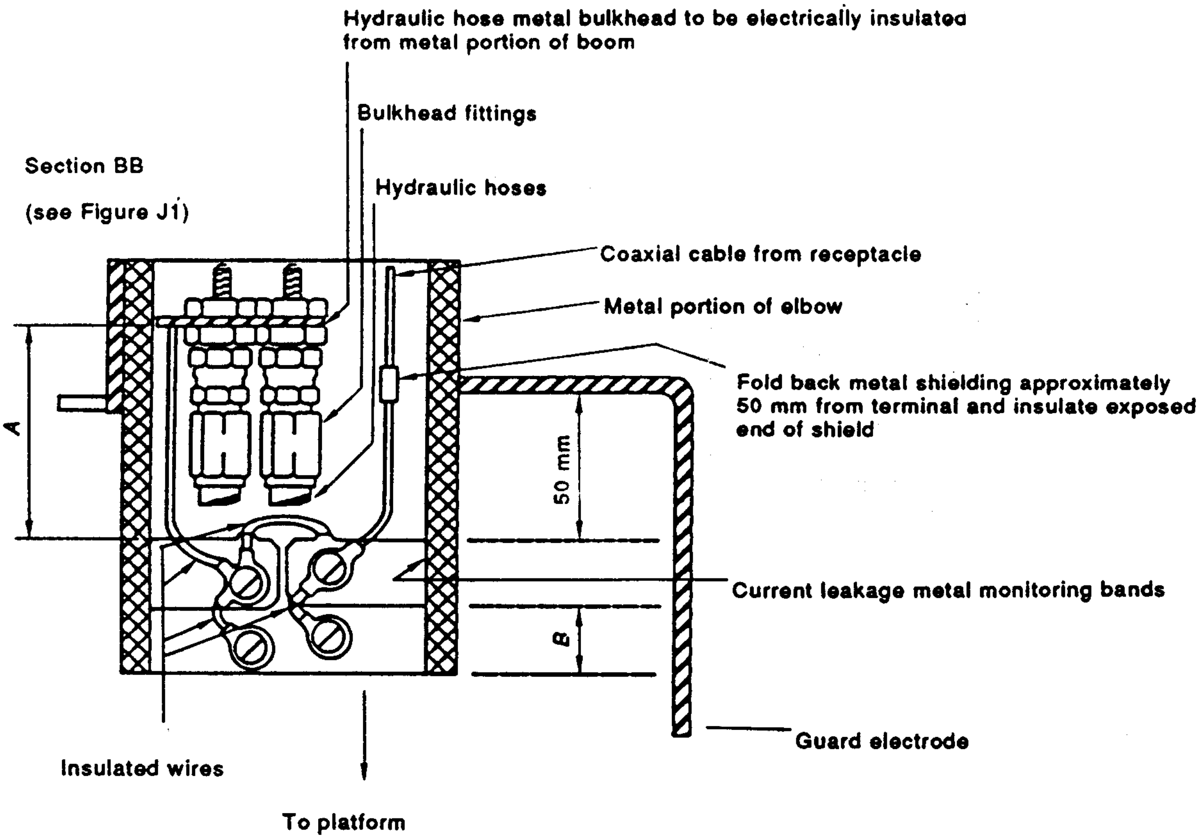

Hydraulic hose metal bulkhead
Current leakage metal monitoring bands
B
B

Figure J1 – Section AA


Hydraulic hose metal bulkhead to be electrically insulated from metal portion of boom
Bulkhead fittings
Section BB
(see Figure J1)
Hydraulic hoses
Coaxial cable from receptacle
Metal portion of elbow
Fold back metal shielding approximately 50 mm from terminal and insulate exposed end of shield
A
50 mm
Current leakage metal monitoring bands
B
Guard electrode
Insulated wires
To platform

(For details, see section AA, Figure J1)

A = The distance between the inner metal monitoring band and the metal bulkhead plate shall be 130 mm minimum to provide electrical shielding of metal hose couplings.

B = The distance between the two leading edges of the metal monitoring bands shall be four times the insulating thickness of the boom.

Figure J2 - Section BB

APPENDIX K
(informative)

User's guide

The rated voltage of an aerial device is equal to the maximum use voltage between the top of the boom and the ground. It corresponds to the nominal voltage between phase and earth of the network on which live working is carried out.

The permitted electrical surges are given in Table I. It is up to the user to verify that they are compatible with those that may occur on his networks. (This verification is particularly important for networks with insulated neutral.) In the opposite case, he should choose an aerial device with a rated voltage higher than the phase to earth nominal voltage of his network.

APPENDIX L
(informative)

Acoustic emission on aerial devices with insulating booms - Test method

L1 Scope

L1.1 This test method describes a procedure for acoustic emission (AE) testing of aerial devices with insulating booms.

L1.2 The AE test method is used to detect and area-locate emission sources. Verification of emission sources may require the use of other non-destructive test (NDT) methods, such as radiography, ultrasonics, magnetic particle, liquid penetrant and visual inspection.

L2 Terminology

L2.1 *Definitions*

L2.1.1 *Acoustic emission (AE)*

The class of phenomena whereby transient elastic waves are generated by the rapid release of energy from a localized source or sources within a material, or the transient elastic wave(s) so generated. Acoustic emission is the recommended term for general use. Other terms that have been used in AE literature include: stress wave emission, microseismic activity and emission or acoustic emission with other qualifying modifiers.

L2.1.2 *Amplitude (acoustic emission signal amplitude)*

The peak voltage of the largest excursion attained by the signal wave-form from an emission event.

L2.1.3 *Amplitude distribution*

A display of the number of acoustic emission events with signals that exceed an arbitrary amplitude as a function of amplitude.

L2.1.4 *Attenuation*

Loss of energy per unit distance.

L2.1.5 *Channel*

An input to the main AE instrument that accepts a preamplifier output.

L2.1.6 *Count, n (acoustic emission count)*

The number of times the acoustic emission signal amplitude exceeds a pre-set threshold during any selected test period.

L2.1.7 *Decibel (dB)*

Logarithmic expression of a ratio of two single peak amplitudes. A common logarithmic amplitude scale expresses the signal peak amplitude relative to a fixed reference level.

$$\text{Signal peak amplitude (dB)} = 20 \log_{10} (A1/A0)$$

where:

A0 = 1 µV at the sensor output (before amplification), and

A1 = peak voltage of the measured acoustic emission signal

Acoustic emission reference scale

dB value	Voltage at sensor output
0	1 µV (A0)
20	10 µV
40	100 µV
60	1 mV
80	10 mV
100	100 mV
120	1 V

L2.1.8 *Event (acoustic emission event)*

A local material change giving rise to acoustic emission.

L2.1.9 *Event count* (N_e)

The number obtained by counting each discerned acoustic emission event once.

L2.1.10 *First hit*

A mode of operation of AE monitoring equipment in which an event occurring on one channel will prevent all other channels from processing data for a specified period of time. The channel with a sensor closest to the physical location of the emission source will then be the only channel processing data from that source.

L2.1.11 *Noise*

Any undesired signal that tends to interfere with the normal reception or processing of the desired signal.

L2.1.12 *Signal (emission signal)*

A signal obtained by detection of one or more acoustic emission events.

L3 Summary of method

L3.1 This test method consists of applying a predetermined load to aerial devices while they are being monitored by sensors that are sensitive to transient stress waves (AE) caused by growing defects. These stress waves can be generated by, but are not limited to, the following:

- crack nucleation or propagation in the metal components; or matrix crazing, delamination or fibre breakage of the fibreglass reinforced plastic (FRP) material; or both.

L3.2 The aerial device is loaded at a uniform rate until a predetermined load is reached, which is held for a period of time. The load is removed and the cycle is repeated. Acoustic emissions are monitored during both cycles and the data is evaluated (see Fig. L3).

L4 Significance and use

L4.1 This test method provides a means of evaluating transient stress waves generated by the rapid release of energy from localized sources within an insulated aerial device under controlled loading. The resultant energy releases occur during intentional application of a controlled predetermined load. These energy releases can be monitored and interpreted.

L4.2 This test method permits testing of the major components of an aerial device under controlled loading. This test method utilizes objective criteria for evaluation and may be discontinued at any time to investigate a particular area of concern or prevent a fault from continuing to ultimate failure.

L4.3 This test method provides a means of detecting emission sources that may be defects or irregularities, or both, affecting the structural integrity or intended use of the aerial device.

L4.4 Sources of emission found with this test method should be evaluated by either more refined acoustic emission test methods or other non-destructive techniques (dye penetrant, X-ray, ultrasonics, magnetic particle, etc.). Other non-destructive tests may be required to locate defects present in the aerial devices.

L4.5 Defective areas found in aerial devices by this test method should be repaired and retested as appropriate. Repair procedure recommendations are outside the scope of this test method.

L5 Test preparation

L5.1 Prior to the AE test, a visual observation of the aerial device shall be performed to ensure that the components to be tested are free from any condition that may prohibit the test or adversely affect test results.

L5.2 The components to be monitored in an aerial device shall include, but not be limited to, those listed in Table L1. Additional channels and sensors may be used to supplement the minimum test requirements and improve location resolution.

L5.3 Position the sensors on the FRP and steel portions of the components identified in Table L1. The extent of the coverage is determined by the number of sensors used and the attenuation characteristics of the individual components. Record the amplitude of the lead at a distance of 300 mm from the reference sensor. Continue to move the pulser away from the sensor until the amplitude is no more than 15 dB less than the reference amplitude. This will establish the maximum area of coverage of the sensor.

L6 Test procedure

L6.1 Test the articulated aerial device in positions such that the components indicated in Table L1 can be monitored. Recommended test positions as illustrated in Figure L1 or their equivalents may be used.

L6.2 Test the extensible aerial device in positions such that the components indicated in Table L1 can be monitored. Recommended test positions as illustrated in Figure L2 or their equivalents may be used.

L6.3 Attach the load measuring device to the load application system which in turn shall be attached to an adequate dead weight or anchor.

L6.4 The load connection technique used should simulate in-field use as closely as possible.

L6.5 Perform the loading sequence as illustrated in Figure L3.

L6.6 As a minimum, record the following data during the test:

L6.6.1 Events by channel (events versus time).

L6.6.2 Counts versus time or load for metal channels.

L6.6.3 Counts versus time or load for fibreglass channels.

L6.6.4 Amplitude distribution for metal channels.

L6.6.5 Amplitude distribution for fibreglass channels.

L6.6.6 Load versus time.

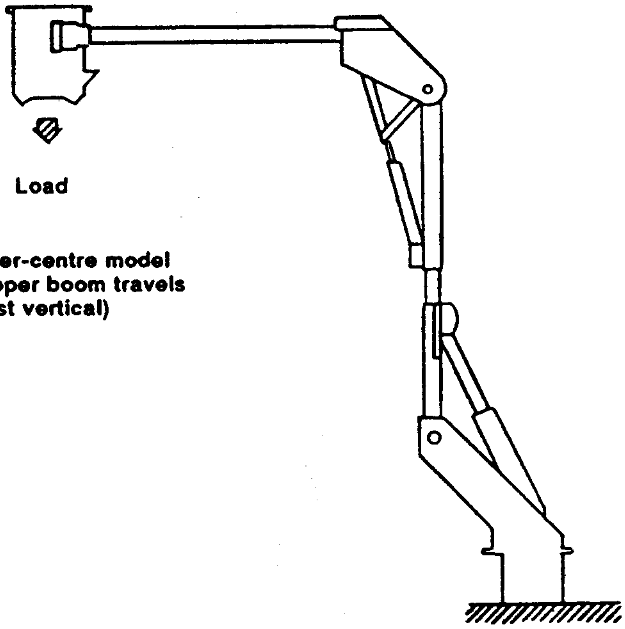
Table L1 - Aerial device components to be monitored with acoustic emission

Components	Identification *	Articulated aerial device **	Extensible aerial device ***
Platform	A	x	x
Platform attachment	B	x	x
Upper boom	C	x	x
Upper and lower boom attachment of elbow	D	x	NA
Upper and lower section of lower boom	E	x	NA
Insulating gap (lower boom)	F	x	NA
Turntable and rotation bearing	G	x	x
Pedestal	H	x	x
Intermediate boom	I	NA	x
Lower boom	J	NA	x

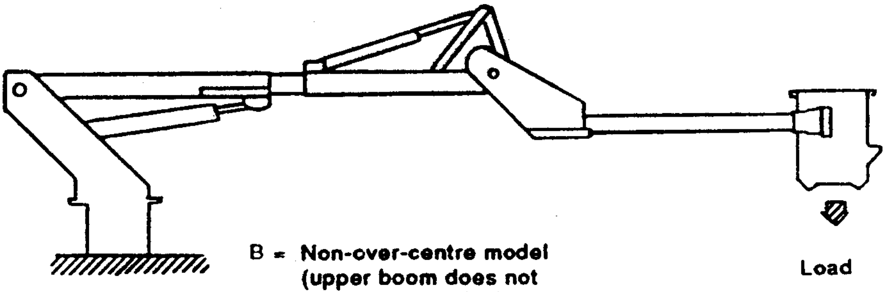
* Refer to Figures L4 and L5 for illustration of components.

** The use of symbol "X" indicates the need to monitor this component with acoustic emission.

*** The use of symbol "NA" indicates that acoustic emission does not apply.



A = Over-centre model (upper boom travels past vertical)



B = Non-over-centre model (upper boom does not travel past vertical)

Figure L1 - Test positions for articulated aerial devices

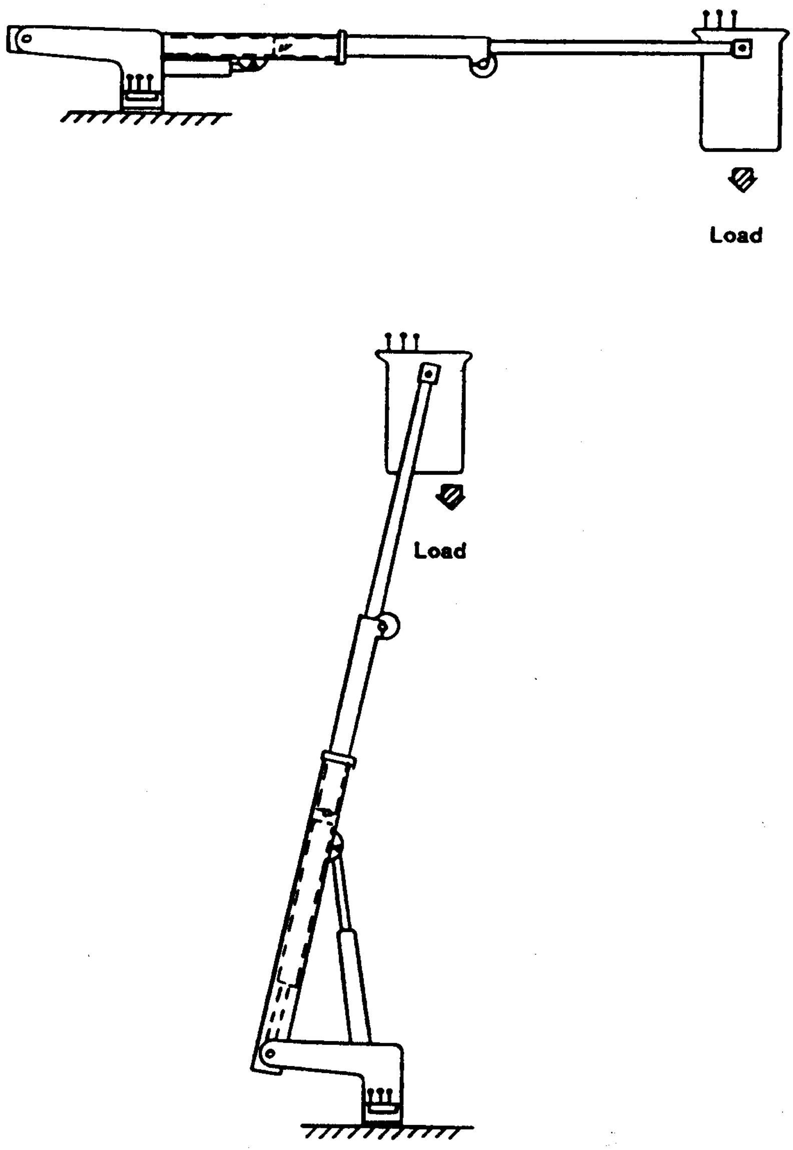


Figure L2 - Test positions for extensible aerial devices

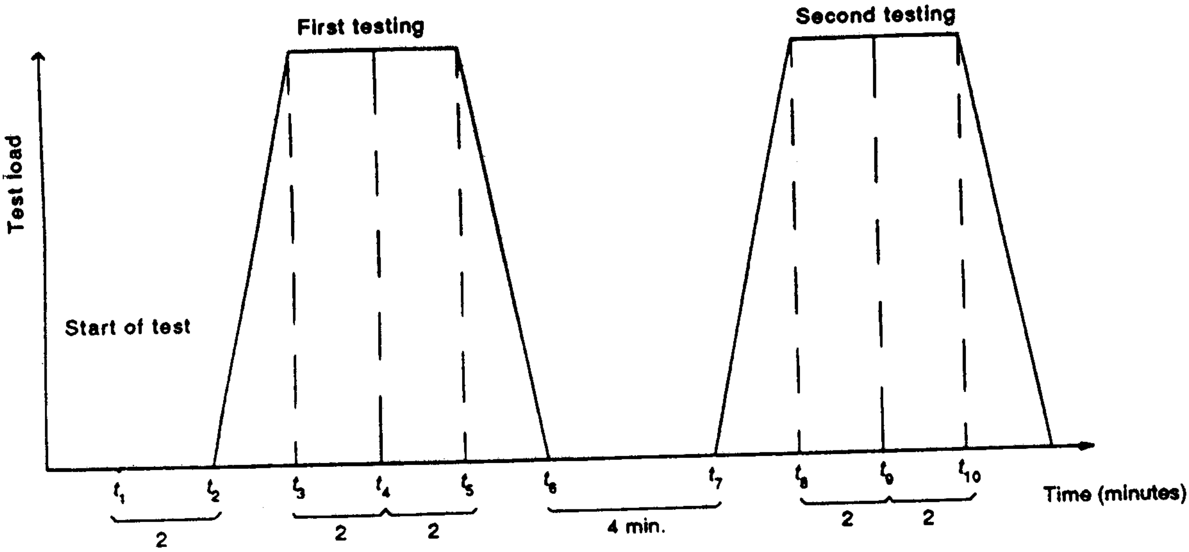
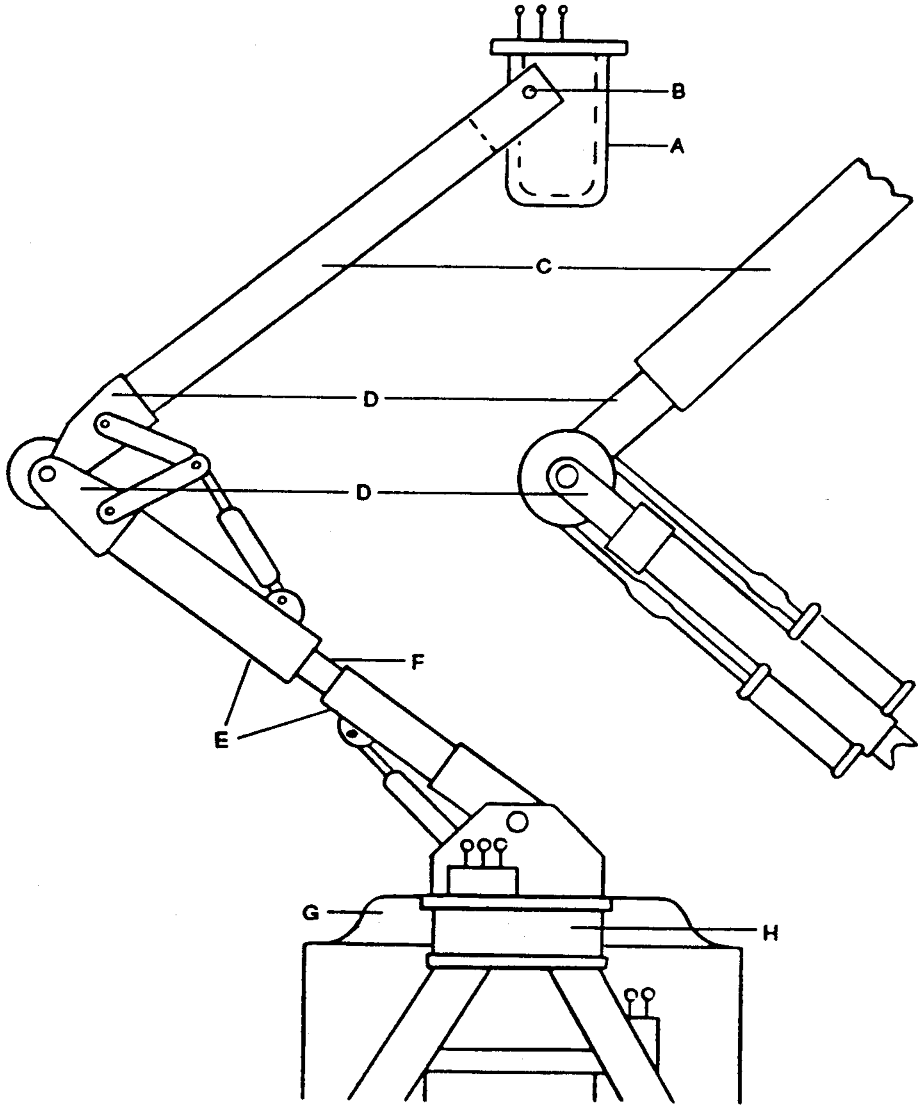


Figure L3 - Aerial device loading sequence



NOTE - Refer to Table L1

Figure L4 - Components of an articulated aerial device to be monitored with acoustic emission

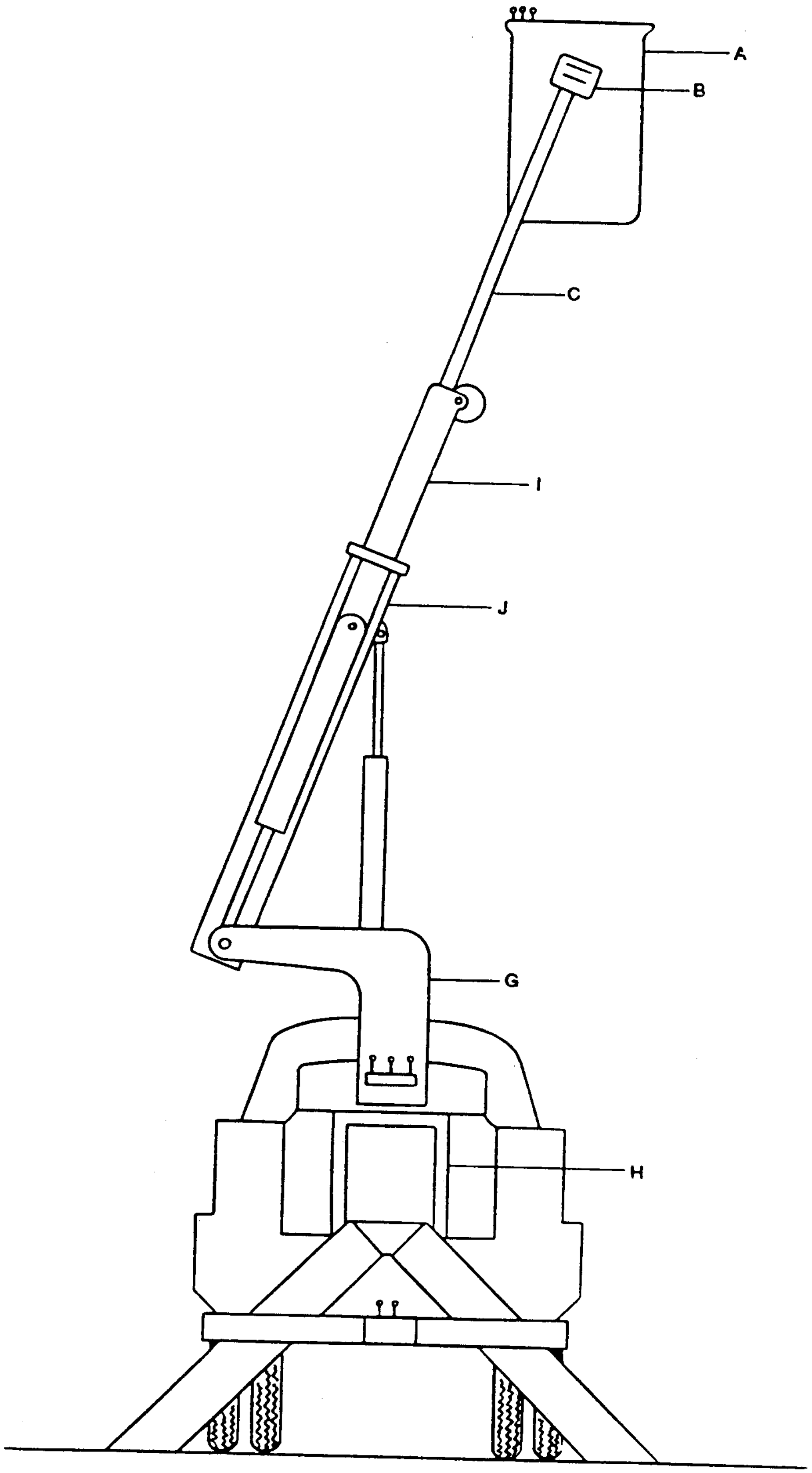


Figure L5 - Components of an extensible aerial device to be monitored with acoustic emission

(Continued from second cover)

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
	IS 11731 (Part 2) : 1986 Methods of test for determination of the flammability of solid electrical insulating materials when exposed to an igniting source: Part 2 Vertical specimen method	Not Equivalent
IEC 60855 (1985) Insulating foam-filled tubes and solid rods for live working	IS 13770 : 1993 Insulating foam-filled tubes and solid rods for live working	Identical
ISO 1219 : 1991 Fluid power systems and components — Graphical symbols and circuit diagrams — Part 1: Graphic symbols	IS 7513 : 1974 Graphical symbols for fluid power systems	Not Equivalent
ISO 4302 : 1981 Cranes — Wind load assessment	IS 14467 : 1997 Cranes — Wind load assessment	Identical
ISO 4305 :1991 Mobile cranes — Determination of stability	IS 14469 : 1997 Mobile cranes — Determination of stability	do
ISO 6605 : 1986 Hydraulic fluid power — Hose assemblies — Method of Test	IS 12092 :1987 Method of test for hose assemblies used in hydraulic fluid power systems	Equivalent

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that it is acceptable for use in conjunction with this standard:

IEC 60212(1971)	Standard conditions for use prior to and during the testing of solid electrical insulating materials
IEC 60247(1978)	Measurement of relative permitivity, dielectric dissipation factor and d.c. resistivity insulating liquids
ISO 1219-2:1995	Fluid power systems and components — Graphical symbols and circuit diagrams — Part 2: Circuit diagrams

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 :1960 'Rules for rounding of numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act,* 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc : No. ET 36 (3855).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
Telephones : 323 01 31, 323 33 75, 323 94 02

Telegrams: Manaksanstha
(Common to all offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110 002	323 76 17 323 38 41
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Kankurgachi CALCUTTA 700 054	337 84 99, 337 85 61 337 86 26, 337 91 20
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160 022	60 38 43 60 20 25
Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600 113	235 02 16, 235 04 42 235 15 19, 235 23 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400 093	832 92 95, 832 78 58 832 78 91, 832 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM.

Printed at New India Printing Press, Khurja, India